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to the author...

A SYSTEM OF

OPHTHALMIC OPERATIONS

Being a Complete Treatise on the Operative Conduct of Ocular Diseases and Some Extraocular Conditions Causing Eye Symptoms.

Edited and Partly Written by

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Completely Indexed and Illustrated with Eighteen Color Plates and over One Thousand Drawings in Black and White, Many of them Original

Complete in Two Volumes

VOLUME I

Chicago:
CLEVELAND PRESS
1911

TO

HERMAN KNAPP

TEACHER, WRITER, COUNSELLOR,

IN GRATEFUL ACKNOWLEDGMENT OF HIS

EMINENT CONTRIBUTIONS TO

OPHTHALMIC SURGERY

The eye may be said to resemble a microcosm, in which may be discovered all the various morbid changes which take place throughout the other organs and tissues of the body.

A Treatise on the Diseases of the Eye, George Frick, Baltimore, 1823.

Those who are unacquainted with the anatomy of the eye can only acquire this knowledge perfectly by dissections, which should be repeated on the dead eyes of animals; but particularly of the human subject. A few dissections will impress the mind with more complete ideas of the eye than a thousand written descriptions.

A Treatise on One Hundred and Eighteen Principal Diseases of the Eyes and Eyelids, William Rowley, London, 1790.

Wenn man also die Augen mit allem fleisse besichtiget hat, und des Stares gantz eigentlich wargenommen, und dessen gar gewiss ist, das es ein guter Star, und keine gefahr oder mangel verhanden ist, mag man solche Personen in Gottes Namen annemen, und dieselbige Kunst, so er der Artzt wol gelernet haben sol, an den *Patienten* mit hohem fleisse und grossem verstande, vorsichtiglichen fürnemen, uben und gebrauchen. Dardurch sind, Gott sey lob, gar unzelich viel tausent Menschen, Mans und Weibespersonen, mit Gottes hülffe, und durch diese herrliche Kunst, aus der stockblindheit und elenden betrübten finsternüs dieser Welt errettet und geholffen worden.

OPHTHALMODOULEIA. Das ist Augendienst, George Bartisch von Königsbruck, Dresden, 1585.

L'Art de guérir, quoique fondé sur un bon nombre de principes vrais et constants, a encore besoin d'être étayé de l'Observation et de l'Expérience, qui sont les véritables pierres de touche à la faveur desquelles nous pouvons distinguer le vrai du faux; sans elles cet art utile seroit encore dans l'enfance; en effet, toutes les découvertes, soit en Anatomie, soit dans les divers traitements anciens et modernes, n'ont été faites qu'à l'aide de l'Observation et de l'Expérience.

Mémoires et Observations Anatomiques sur l'Oeil, Jean Janin, Paris, 1772.

La Notomia è la bussola infallibile dell'arte del medicare. Il suo lume è quello che ci serve di guida nelle malattie, che da noi s'intraprendono a curare; senza la sua scorta tutto è labirinto, tutto è coperto dal più denso velo dell' ignoranza.

Lezioni Intorno alle Malattie degli Occhi, Michele Troja, Napoli, 1780.

PREFACE

The plan that has been followed in this *System,* dealing with the operative side of ophthalmology, much resembles that adopted when treating its medical aspects in the *System of Ophthalmic Therapeutics.* Indeed, the present volumes are intended to supplement and form with that treatise a reasonably complete exposition (from the earliest to the latest times) of ocular therapy, both medical and surgical.

As may be readily imagined, the task of writing a complete treatise on ophthalmic operations is beset with many inherent difficulties that are much increased when the space at one's disposal is limited. A truly complete account (properly illustrated) of all the surgical procedures that, from the earliest times, have been resorted to for the relief of ocular symptoms cannot be compressed within the covers of two volumes, it matters not what their size may be. However, it is hoped that, in the present instance, no really important operation has been omitted and that the reader will find the illustrations helpful in elucidating the text.

The line that divides general from ophthalmic surgery is constantly shifting; it is not that well-defined boundary that some writers would have us believe. For this reason I asked Dr. Halstead to contribute a chapter descriptive of those operations on distant organs that most commonly involve the eye, and I believe that he has described no operation that the ophthalmic surgeon may not do if he is so disposed.

For precisely the same reason Dr. Brawley has written a chapter in which are detailed those operations on the nose and adjacent cavities necessary to relieve eye symptoms. In any event, the ophthalmologist should be instructed regarding the latest methods employed in these operations, even if he does not do them himself.

It might also be asserted that the Forensic Relations of Ophthalmic Surgery have no part even in a systematic treatise on Ophthalmic Operations. Yet every American ophthalmic surgeon knows only too well that every time he essays an operation he invites a suit (or a threatened suit) for malpractice. It seemed to the Editor, therefore, that a chapter on this appropriate subject would be a welcome and useful feature of the *System,* especially as the data here printed have never before been gathered and given by the profession in the

accessible shape presented by Dr. Shastid. They ought to be of considerable value to the surgeon, and of some assistance to his lawyer.

It is inevitable that certain *repetitions* occur in a work of this kind and magnitude; but it may be said that the majority of them in this *System* are intentional. References to a section, a cut or a plate on another page, or in another volume, are often found with some difficulty, and even when the search has been successful the effort much interferes with the concentration of thought required to grasp the descriptive details of an operation. In the interest of the student, therefore, this drawback has, in certain instances, been avoided by duplication.

The orthoëpic rules followed in the *System of Ophthalmic Therapeutics* have been adopted in the spelling of words in this *System*. As before stated by the Editor:—"In my humble judgment the spelling of words used by English peoples throughout the globe properly varies in different continents, and even in small subdivisions of these continents. It is useless, therefore, to lay down arbitrary rules for spelling or pronunciation, especially in a work intended to circulate among English-speaking people generally. In consequence of this I have decided not to attempt uniformity of spelling either on the part of my collaborators or myself. In any event, it strikes me as unimportant whether cocaine is spelt with or without an *"e,"* whether we write it *"physiologic"* or *"physiological,"* whether the second syllable of anesthesia is spelled with a diphthong or whether *center* terminates in *re* or *er*, or tumor in *or* or *our*. Each contributor is allowed to do as he pleases in this regard."

The Editor and his Collaborators are under particular obligation to their colleagues, not only in America but in other parts of the world for a goodly portion of the material acquired in the preparation of this *System*. Furthermore, as will be seen by the footnotes, writers of the various chapters have quoted from many text-books, monographs and papers dealing with the subject under discussion. As far as possible, full credit has been given for this assistance.

Among the many treatises on the surgery of the ocular apparatus to which they are especially indebted may be mentioned Norris and Oliver's *System of Diseases of the Eye*, Czermak and Elschnig's *Die Augenärtzliche Operationen*, Beard's *Ophthalmic Surgery*, Terrien's *Chirurgie de l'Oeil*, the two Editions of the Graefe-Saemisch *Handbuch der gesamten Augenheilkunde*, the *Encyclopédie française d'Ophtalmologie*, Grimsdale and Brewerton's *Text-Book of Ophthalmic Operations*, and Meller's *Ophthalmic Surgery*.

Both the Editor and the Publishers of this *System* wish to acknowledge, with thanks, the permission of Messrs. P. Blakiston's Son

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The Editor also desires to acknowledge the valuable services of the principal illustrator, Dr. Charles G. Willson of Chicago, who has made many hundreds of successful drawings, sometimes from the most meagre sketches and descriptions.

He is much indebted, also, to Miss Josephine L. Schroeder and Miss H. A. Fox for their valuable assistance while the proof sheets were passing through the press; and to Miss M. K. Chapin for her careful preparation of the Index.

CASEY A. WOOD.

Chicago.

TABLE OF CONTENTS

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PART I.

BIOGRAPHICAL SKETCH OF SOME REPRESENTATIVE OPHTHALMIC SURGEONS.

Ancient, Medieval and Modern, with an Account of Operations They Originated or Improved.

By MORTIMER FRANK, B. S., M. D., Chicago.

Ophthalmology Among the Ancients—Ophthalmic Surgery Among the Ancient Egyptians—The Surgical Treatment of Pterygium by the Ancient Greeks—Ophthalmology Among the Arabians—Avicenna—The Ancient Roman Oculist—Oculists' Seals and Stamps—Collyria—Medieval Ophthalmology—Bartisch of Königsbruck—Itinerant Oculists in the Middle Ages—Couchers and "Eye Destroyers"—The Rise of Scientific Ophthalmology—Kepler and Descartes—Ancient and Medieval Theories About Cataract—Maitre-Jean—Jacques Daviel—William Cheselden—Joseph Beer—Early Ophthalmic Surgery in France—Tenon—Petit—Descemet—Early Ophthalmic Surgery in Germany—Zinn—Joh. Schmidt Himly — Barth — The Jaegers — Rosas — William Mackenzie — Thomas Young—Traveling Quacks in the Seventeenth and Eighteenth Centuries—Woolhouse—John Taylor—Trachoma in Europe—Ophthalmology in Great Britain During the First Half of the Nineteenth Century—Saunders — Guthrie — Wardrop — Tyrrell—Gibson—German Ophthalmic Surgeons in the Beginning of the Nineteenth Century—Jüngken—von Ammon—Arlt—von Graefe—Dieffenbach—Nineteenth Century Ophthalmic Surgeons in France—Bonnet—Sichel—Carron du Villars—Desmarres—Ophthalmic Surgery in America—Frick—Delafield—Isaac Hays—Dix—Bolton—The Invention of the Ophthalmoscope—Helmholtz—Donders—Cuignet.

Ophthalmology Among the Ancients.

The early history of medicine resembles that of most kingdoms; it is filled with fable and conjecture, and rests upon dubious traditions. We have few historical records to guide us and perhaps, after a tedious search, certainty would add very little to the fund of medical knowledge.

In the earlier periods ophthalmic medicine and surgery did not form a distinct department of the science of medicine. For example, Celsus, judging from his works, appears to have been no less skilled

in this than in all other branches of the healing art. While the greatest progress in ophthalmology may be said to date from the discovery of the ophthalmoscope, yet its invention merely marks an epoch in the evolution of that science; for many important advances had been made before and some have been achieved since it came into use.

Ophthalmic Surgery Among the Ancient Egyptians.

Throughout all antiquity the Egyptian physicians enjoyed special reputation in the treatment of diseases of the eyes. They must therefore be regarded as the earliest oculists. They were summoned even to foreign courts, and furnish us the earliest examples of practitioners who travel among alien people, and we read of one who was sent for to treat the eyes of the mother of Cyrus the Persian.

The treatment of diseases of the eye during this early era was essentially of a religio-magical character; it was the priest who possessed the sole power to heal the sick. Whenever a patient desired aid in an affection of the eyes he summoned a special priest-physician from the nearest temple, who prescribed such remedies as were mentioned in the Laws collated from the writings of the oldest medical authorities. In ophthalmic surgery these priestly oculists were especially skilful and it is highly probable that they even operated for *cataract,* although the Egyptian had no idea that the crystalline lens is the seat of cataract. When we stop to consider that cataract was unrecognized as a disease of the lens until 1700, A. D., our respect for the knowledge of the Egyptians increases.

The Egyptians were also acquainted with *pterygium,* as well as with various inflammatory diseases of the conjunctiva caused by the irritating dust and sand particles with which the Egyptian air is often filled.

The ophthalmology of Hippocrates was limited to an acquaintance with the external and manifest disorders of the eye such as tumors, ectropion, entropion, hordeolum and epidemic inflammations of the conjunctiva. Operative measures were also resorted to for the relief of trichiasis.

Ophthalmology Among the Arabians.

The Arabs had many oculists and as early as 1283 separate ophthalmic wards were introduced by them into their general hospitals. They published many ophthalmic text-books, most of them mere compilations from the ancients, but that they possessed an extensive knowledge of diseases of the eye is proved by the accuracy of their descriptive matter.

There is a well-preserved, medieval-Latin edition, printed and painted during the years 1489-91 by Boetius, of Venice, of the re-

nowned surgeon-oculist Avicenna, or Abu Ali El Hosein Sina, born in Bokhara about A. D. 925. The fifth book of the folio is entirely devoted to a description of the eye and its diseases. It was mainly from this source that the sixteenth century English surgeons drew their in-

Fig. 1.

Surgical and Ophthalmic Instruments found in Upper Egypt. (M. Meyerhof, Cairo, Egypt.)

spirations. Then, as now, it was considered proper in every general work on medicine or surgery to set aside at least a few chapters to a consideration of the ocular apparatus and its diseases.

Early Greek ophthalmology is associated with Æsculapius, the God of Medicine, whose temple-walls were covered with thank-offerings in the form of votive tables bearing inscriptions giving the nature of the disease for which help had been implored and a description of the cure. That ophthalmology was specialized among the Greeks is proven by Plato when he says that the treatment of diseases of the eyes should be undertaken by those who have shown themselves capable and who have made an exhaustive study of the eye, otherwise physicians who had not this training should be prohibited from even examining the eye.

Fig. 2.
Votive Tablet representing a Pair of Eyes, with the Inscription, "Philematin dedicated [this] as a Votive Offering." (British Museum. Kershaw.)

The Surgical Treatment of Pterygium by the Ancient Greeks.

The treatment of pterygium consisted in raising the growth by means of a small, sharp hook and passing underneath it a needle carrying a horsehair and a strong thread. Tension being made on the thread by an assistant, the operator sawed off the apex of the pterygium by means of the horsehair. The base of the growth was then severed with a scalpel. Following another method the pterygium was dissected from its bed, while it was stretched as before, with an instrument called a *pterygotome*—a procedure almost identical with some of the operations in vogue at the present day.

Although ignorant of the pathology of cataract, the nature of the disease seems to have been well understood and a full description of *depression* is given by Paul and Celsus. The instrument used for depression, as described by Paul, consisted of a handle having at one end a nucleus to mark the spot at which to penetrate the cornea; and a needle at the other.

Epilation as a purely surgical operation was frequently necessary for trichiasis consequent on trachoma, so common among the Greeks and Romans. Paulus Ægineta also minutely describes a plastic operation for entropion—a procedure that seems to have been frequently required.

The Ancient Roman Oculist.

Ophthalmology as a specialty among the Romans declined as soon as it was found "that there was money in it." The rush for a lucrative

Fig. 3.
Pterygotome (Milne).

medical practice was immense, particularly as from the outset it was governed by the laws of free-trade and the door flung wide open to the ignorant and impure elements of society.

Oculists' Seals or Stamps.

The Roman oculists eventually became mere concocters of eye-salves. Their ointment-pots and *business stamps* have been found in almost every land where the Roman legions were stationed or the Roman eagles flew. *Trachoma* must have been very frequent among the Roman soldiers inasmuch as copper sulphate is one of the ocular remedies most frequently spoken of. That so many stamps or

Fig. 4.
Depression Needle (Milne).

seals have been preserved probably depends upon the fact that all ophthalmic diseases, including errors of refraction, were treated solely by medication. The *collyria* of the ancient Romans bore, like our toilet soaps, the stamp of the proprietor or inventor. The vessels in which these collyria and eye-salves were stored, and even the remedies themselves bearing the stamps in question, have been discovered in great

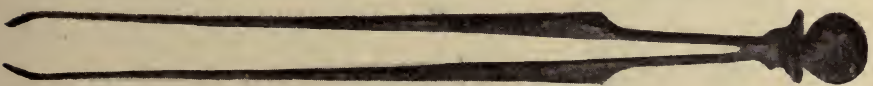

Fig. 5.
Epilation Forceps (Milne).

numbers throughout Germany, England and France, especially in localities where the permanent camps of the Roman legions were pitched.

When salves and lotions were of no avail the Roman oculist resorted to bleeding, antiphlogistics, scarification, cupping or to the actual cautery.

Fig. 6.
Ancient Greek Medical Vases (Simpson).

How the public of that day looked upon the oculist may be inferred from the following extracts from the Satires of Martial—"Now

you are a gladiator, once you were an oculist; you did as a doctor what you do as a gladiator."

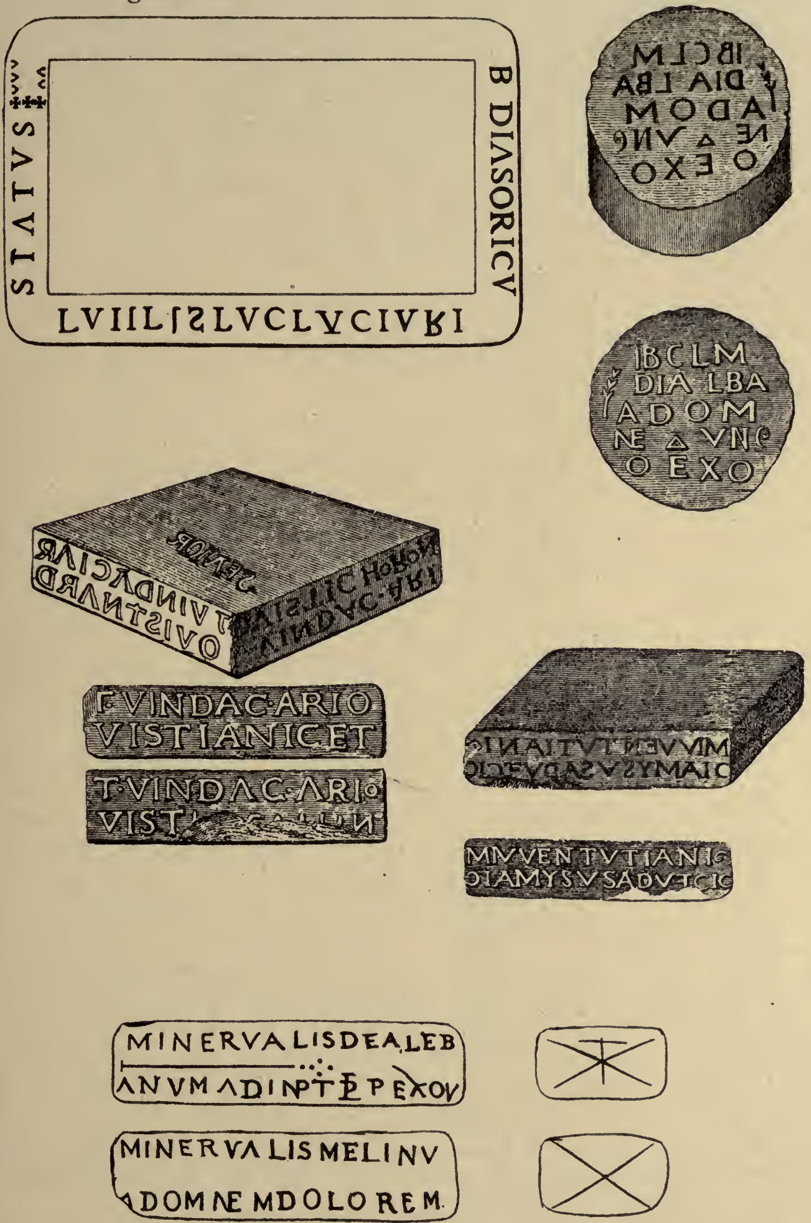

Fig. 7.
Ancient Roman Medicine-Stamps (Simpson).

In another place he says, "The blear-eyed Hylas would have paid you sixpence, O! Quintus; one eye is gone, he will still pay threepence;

make haste and take it; brief is your chance, when he is blind he will pay you nothing."

Medieval Ophthalmology.

From this time until the middle of the seventeenth century ophthalmology was in the hands of itinerant quacks who reaped a rich harvest from the possession of some supposed specific. It was not until 1583 that ophthalmology was in some degree based upon observation.

Bartisch, of Konigsbruck.

In that year George Bartisch, of Königsbruck (near Dresden), published his "Augendienst," a voluminous hand-book printed in the German language. Even in those days the Germans proved their special talent for ophthalmology, the possession of which they have demonstrated anew during the past hundred years or more. The work of Bartisch opens with certificates of cure, that tell "how, under God's will and the skill of George Bartisch, the eyes of so-and-so were cured." This surgeon was an independent spirit; a man of character and heart, inspired by a love for his profession and of mankind, whom he saw outrageously maltreated in his own department of medicine. This aroused his righteous anger. Every oculist should, in his opinion, be an honest and God-fearing man, and should have studied Latin and the anatomy of the body, especially that of the eye. He specifies very carefully the preparations on the part of both the patient and the physician, necessary before operations. The operating room should be light, the bed well prepared, etc.; and great weight was also laid upon the selection of instruments and the after-treatment of operations. The sole operation he performed for cataract was depression, done through the sclera. Besides this he operated for *pannus, trichiasis, ectropion, lachrymal fistula, symblepharon, ptosis,* tumor of the lid, and many other conditions. He deserves special mention for enucleation of the eye, which he was the first to suggest and perform. (See Dr. Allport's chapter).

How highly Bartisch, in contrast with the "couchers and eye-destroyers" of his day, estimated the responsibility and the calling of the operative ophthalmologist may be inferred from the fact that he insisted on the utmost possible technical dexterity, and an equal use of both hands.

He utters a word of warning against spectacles, which were the fashion in his day: "It is better to have two eyes than four," is his pithy remark.

Itinerant Oculists in Medieval Times.

Traveling oculists, both in England and Germany, were numerous during the sixteenth and seventeenth centuries. Their plan was to gain

Fig. 8.
Couching of Cataract (Bartisch).

the friendship of some petty Prince and thus acquire great social and pecuniary advantages, as did Banister, for example, and Sir William Read, in England. In the seventeenth century the authorities began

to open their eyes to the frauds practised by these mountebanks. Their determination to suppress quackery, coupled with the increased scientific activity of the time, as seen in the observations of Newton, Kepler, Descartes and Scheiner on the functions of the different parts of the eye, led skillful surgeons to the study of this organ.

The Rise of Scientific Ophthalmology.

Foremost among them was Boerhaave who was the first to give separate lectures on ophthalmology, and probably the first to employ the magnifying lens in the examination of the eye.

Most important discoveries relative to the structure and functions of the eye were made during this period.

Joh. Kepler, astronomer and physician, recognized the lens as a part of the refractive system of the eye, explained the function of the retina and discovered the cause of myopia. The changes in the curvature of the lens during accommodation were noticed by the Jesuit Scheiner, who also demonstrated the incidence of images on the retina and studied the movements of the pupil. Descartes explained how images are seen erect and single, and compared the eye to a *camera obscura,* while Mariotte demonstrated the "blind spot."

Ancient and Medieval Theories About Cataract.

The renaissance in ophthalmology came with the discovery by Pierre Brisseau and Antoine Maître-Jean in 1705 that cataract is not a film in front of the crystalline lens but the opaque lens itself. In the first century of our era Demosthenes formulated the first recorded theory as to the nature of cataract, namely, that between the pupil and the lens an effusion arises, the coagulation of which forms cataract. At that time the lens was thought to be situated much farther back than it is and to be the seat of vision.

Galen knew that the lens becomes opaque but never associated it with cataract. Fabricius ab Aquapendente, the eminent teacher of Harvey, first showed, about 1600, the exact position of the lens in the human eye. The Parisian surgeons, Rémy Lasiner and François Quarré in 1650 recognized the true seat of cataract but, although followed by Morgagni, Pierre Borel, Schalling, Gassendi and Plempius, who held similar views, the majority of surgeons adhered to the old theory.

Brisseau was the first to demonstrate by dissection that the lens is clouded in cataract. The *Académie,* to which he communicated his observations, at first declined to accept his conclusions and the responsive uproar in the ophthalmological world silenced Brisseau until Maître-Jean, the famous *chirurgien-major* of the *Hôtel des Invalides,* marched to his support.

Maître-Jean, while couching a cataract, twenty years before, saw

the opaque lens escape from his needle and slip into the anterior chamber. He examined it *in situ* and found it to be a double convex body just like an astronomical lens and not at all like a film. At a post-mortem in 1692 he proved that the opaque lens and cataract were one and the same thing. Although he disputes with Brisseau the honor of first recognizing the true seat of cataract, it was not until 1707, two years after Brisseau's communication, that Maître-Jean published his treatise. The operation of depression which, from its painful consequences and numerous failures, had been largely abandoned by respectable surgeons had fallen into the hands of ignorant quacks. The chief effect of this discovery was the conviction that a cataract could and ought to be extracted rather than couched, and many opponents of the former method became converts to the new theory. Prominent among these were Saint Yves, Petit and Morand in France, Heister, Huggins and Müller in Germany, the famous Boerhaave in Holland, Valsalva, Morgagni, Benevoli and Cocchi in Italy and Cheselden and that prince of mountebanks, John Taylor, in England.

Jacques Daviel.

To Jacques Daviel belongs the honor of introducing the operation for senile cataract by the modern method. A few daring operators had, however, like Steven Blaukaart, in 1688, and Saint Yves and Petit, ventured to extract cataracts which had become dislocated into the anterior chamber. Daviel's first publication appeared in 1748, but his chief communication was made in 1752 before the French Academy of Sciences. Daviel's merit is in having defined a precise operation (the flap operation) for cataract extraction. In his earliest operations the corneal section included the lower two-thirds of that tissue but later he reduced his section to include only one-half of the corneal circumference. The corneal incision was commenced with an instrument very much like a modern keratome and completed with curved scissors. The corneal flap was turned upwards and the capsule of the lens incised with a needle. With the fingers on the lower lid the lens was expressed by their pressure.

In England there was a reaction, headed by Percival Pott, against Daviel's operation, and many surgeons, like Benjamin Bell and Scarpa, expressed unfavorable opinions of extraction and reverted to the old operation of depression. The new operation finally found strong adherents in Vienna—such men as Beer and his son-in-law Jäger—who like Rosas, Fischer, Arlt and Hasner, did extraction of cataract by a flap operation in the upper segment of the cornea. With the aid of these friends, including Sichel and Desmarres in France, the operation of extraction was thoroughly established.

The modern operation of linear extraction with iridectomy was made known by Albrecht von Graefe in 1866. In 1885 de Wecker introduced the simple extraction for cataract; and to-day there are many advocates of the extraction of the lens in the capsule, as suggested by

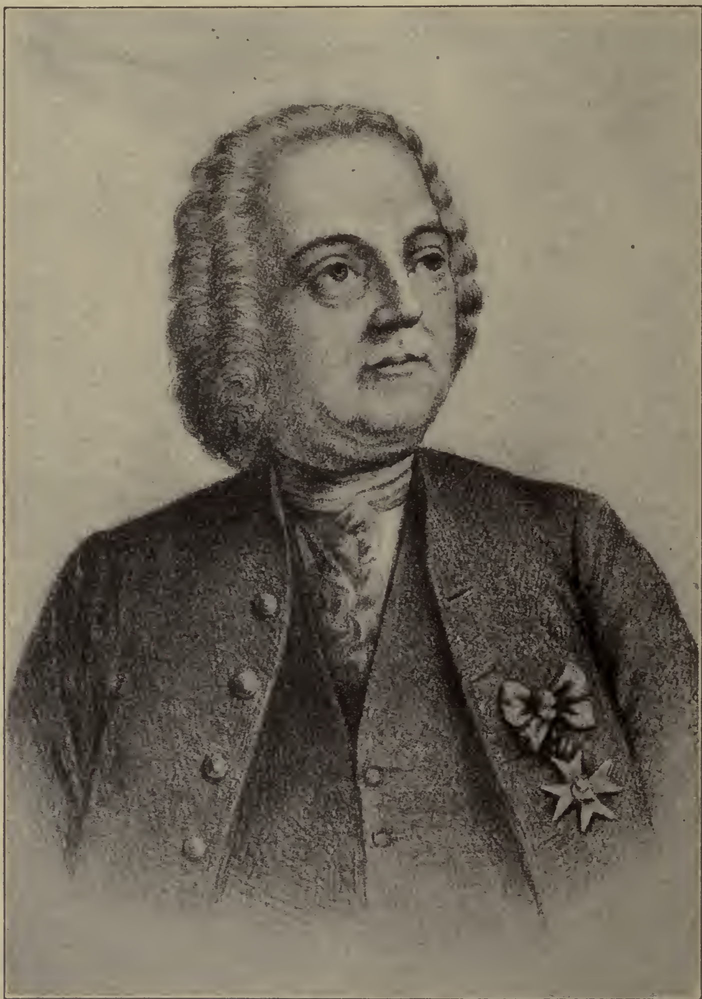

Fig. 9.
Jacques Daviel.

Beer and performed by Lieut.-Colonel Henry Smith, of India, and others.

William Cheselden.

Further advances were achieved in ophthalmology during the first half of the eighteenth century. The formation of an artificial pupil by

Cheselden, Surgeon to St. Thomas' Hospital, London, was almost as great a discovery as that of Daviel. In 1728 he performed for the first time an operation for establishing an artificial pupil, and published a

Fig. 10.

Reproduction of Daviel's Sketch, Showing the Instruments Employed by Him in Making His First Cataract Extraction.

Daviel's Method of Cataract Extraction, Showing the Technique of the Corneal Incision First with the *aiguille pointue* or Keratome, the Enlargement of the Opening with the Blunt-Pointed Knife, the Completion of the Operative Wound with the Scissors, the Opening of the Capsule and the Final Extrusion of the Lens.

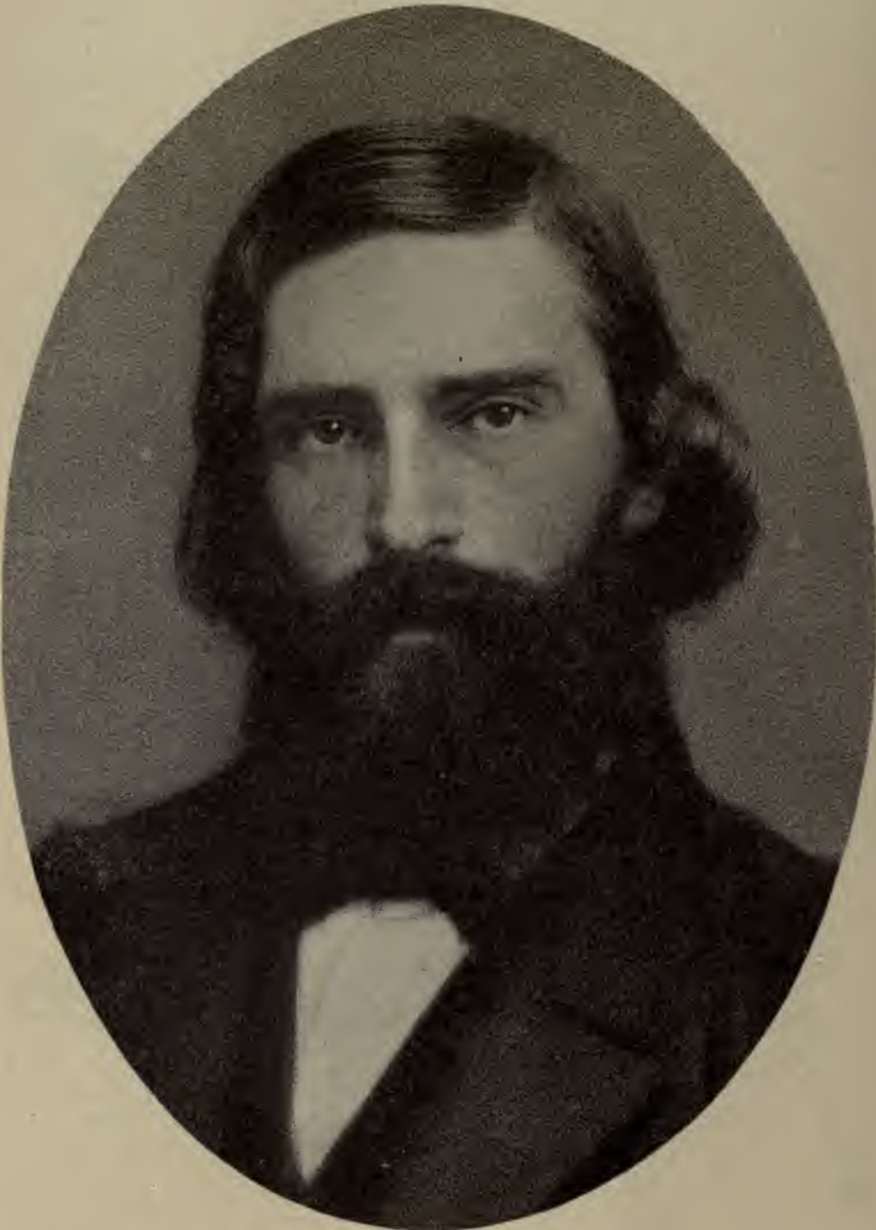

Fig. 11.
Albrecht von Graefe.

communication in the *Philosophical Transactions of the Royal Society*, dealing with his method of thus treating "contracted" iris.

Thomas Woolhouse, a famous but ignorant oculist, in 1711 suggested this operation, but it was not practised.

Fig. 12.
William Cheselden.

Joseph Beer.

To Beer we owe the operation of iridectomy. In 1798 he first drew forth the iris and cut it off to form an artificial pupil.

Early Ophthalmic Surgery in France.

Among the French surgeons who rendered lasting service to ophthalmology is François Pourfour Petit, of Paris, who gave his name to the canal of Petit and suggested the method of examining frozen eyes.

Anel's name is still borne by a syringe and probes, and he was the first to catheterize the lachrymal passages. Other zealous observers were also busy making anatomical discoveries.

Tenon, besides writing essays on cataract and other diseases of the eye, named Tenon's capsule, while Descemet, who was a professor in Paris, will always be associated with Descemet's membrane.

Ophthalmic subjects were about this time also much studied by the Germans and to them we are greatly indebted for the remarkable progress ophthalmology has made from that date to the present.

Early Ophthalmic Surgery in Germany.

Among early German ophthalmologists are Joh. Zinn, a pupil of Haller, whose name has been preserved in the zonula of Zinn; Fontana, who, like Zinn, gave special attention to the eye and named the spaces of Fontana; Reimarus, of Hamburg, who first employed belladonna as a mydriatic and thus rendered a great service to humanity.

Joh. Schmidt, a keen observer, first described syphilitic iritis and called eye disease with great justice "the elegant diminishing mirror of diseases of the body." Since the earliest times iritis had been called inflammatory cataract.

Carl Himly, like Schmidt, was a pupil of Barth and used mydriatics in operations on the eye, while Schmidt was the first to employ them in iritis.

The establishment, in 1773, of the Vienna school of ophthalmology by Barth (under the patronage of Maria Theresa and her son Joseph II, the latter's oculist) was an important step in placing ophthalmology in its correct relation to the other departments of medicine and surgery. He was the first teacher to give separate lectures on ophthalmology. He also had certain wards set apart in the general hospital for ophthalmic cases and so was able to combine practical clinical instruction with his lectures. At the end of the century similar professorships were endowed in other German universities and in France.

Beer extended what Barth had begun and it is upon his teachings and Schmidt's that the fame of the University of Vienna in this specialty is largely founded. Beer was the first to make extensive use of pathology in his teaching of ophthalmology.

Among his eminent pupils was C. F. von Graefe. He was an operator of originality and ingenuity, who used both hands with equal

dexterity and who inaugurated plastic surgery of the eye, though in the latter respect he was far surpassed by his distinguished son, Albrecht. His son-in-law, Friedrich Jaeger, like Rosas, extracted cataract

Fig. 13.
Joh. Reimarus.

beneath a corneal flap and discovered the contagious character of gonorrheal conjunctivitis. His son Eduard later became famous as an ophthalmoscopist and a brilliant operator.

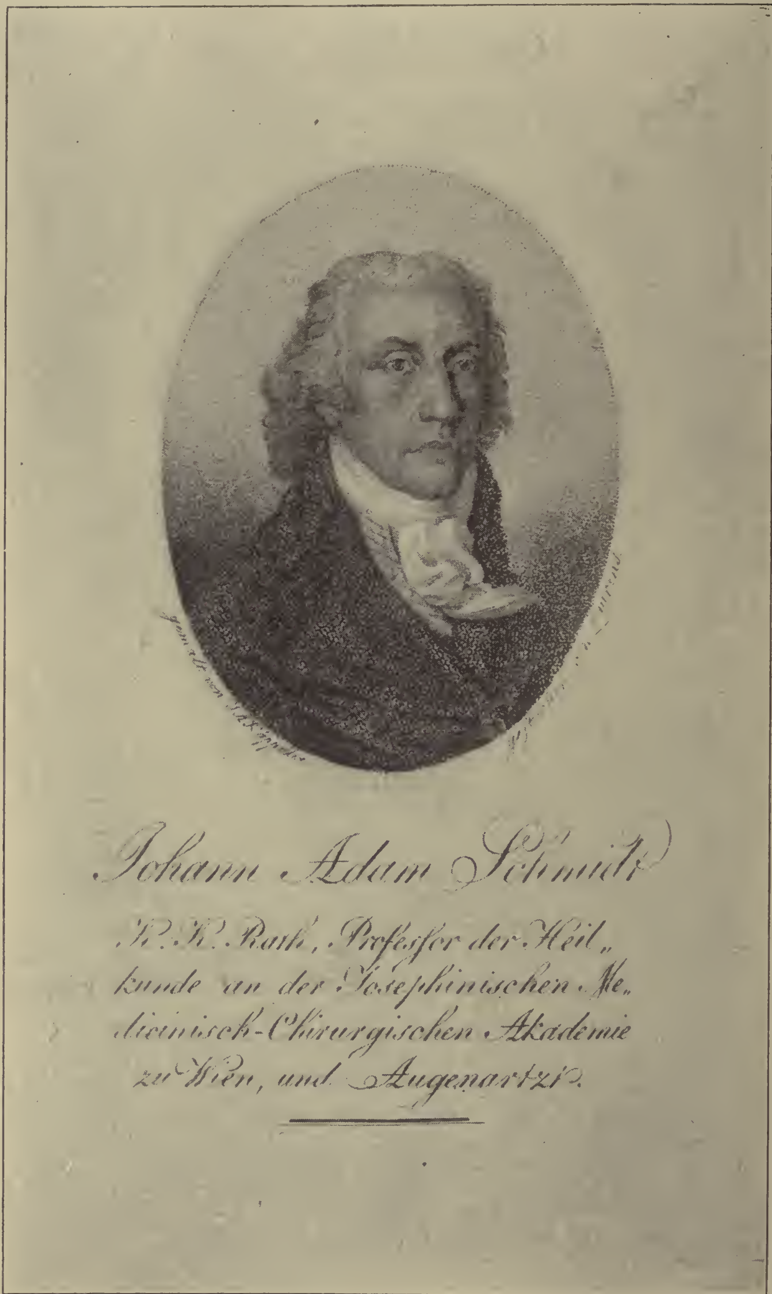

Fig. 14.
Joh. Schmidt.

In addition to these brilliant ophthalmic surgeons one may name William Mackenzie, of Glasgow, who so clearly wrote, among other masterly treatises, one on Sympathetic Troubles and another on Diseases of the Eye in general; Max von Chelius, who founded at Heidelberg the surgical and ophthalmological clinic; and Franz Reisinger, who introduced atropin and hyoscyamin as mydriatics and effected transplantation of the cornea in animals. Among students of the physiology of the eye we should name here the famous Thomas Young—

Fig. 15.
Thomas Young.

physician, physicist and philosopher—who advanced the theory that the seat of accommodation lies chiefly in the crystalline lens; and who developed his theory of color perception. He also gave the first description of astigmatism as a visual defect.

Traveling Quacks in the Seventeenth and Eighteenth Centuries.

Although Barth did not add much to the literature of ophthalmology he made strenuous endeavors to wrest the specialty from the hands of charlatans, but in spite of scientific advances, itinerant oculists still flourished and became even more dangerous to the public because of

flaunting themselves as scientific ophthalmologists. They were no longer content to trumpet their own fame from a stage in front of the booth in which they practised, but, mounted on horseback and preceded by musicians, they marched valiantly along, heralded by laudatory pamphlets and posters not unlike those used in our own day by similar advertising mountebanks. Many of them rejoiced in an extensive clientage. Among the most notorious of the eighteenth century were Woolhouse and Taylor.

Woolhouse was oculist to James II and William III and at one time physician to the *Hospice des Quinze-Vingts* in Paris where he delivered lectures upon diseases of the eye. He is said to have proposed the operation of iridectomy as early as 1711, though it was first performed by Cheselden in 1728. All his works were written in French; one of them, published at Paris in 1696, is entitled *"Dissertation sçavante sur la cataracte et le glaucome, etc."* An addition to this work, published in 1717, contains the following characteristic, laudatory passage: *"Quis autem nescit Woolhusium ad adolescentia sua tot mille cataractas et glaucomata depressisse? Ac proinde ipsum ophthalmiatrorum Europae principem esse?"*

The most remarkable of the charlatans who practised during the first half of the eighteenth century was "the Chevalier" John Taylor, a fellow student of Haller under Boerhaave, and a man by no means ignorant though a thorough mountebank. He traveled through Europe and part of Asia lecturing upon diseases of the eye and operating indiscriminately upon almost anything that offered itself. Taylor's only real merit, so far as one can discover, is that he suggested the division of the muscles of the eye as a cure for strabismus, but never actually performed the operation.

Trachoma in Europe.

In the early years of the nineteenth century a terrible epidemic of "Egyptian ophthalmia" spread throughout Europe—brought by the returning troops of various nations. Commencing among the English and French troops stationed in Egypt it attacked the armies of England, France, Italy and Russia. Some idea of the severity of the disease may be obtained from the fact that in 1818 there were five thousand blind soldiers in England. The virulence of the disease and its extent directed attention to ophthalmic diseases, and the advances made in ophthalmology at this time were no doubt in part due to the eager and even violent discussion of the cause and treatment of this dreadful scourge.

The history of ophthalmology in the first half of the nineteenth century is so full of interest that condense it as we may space can be found for reference to only a small part. Ophthalmic hospitals were

established in the larger cities and special journals devoted to ophthalmology appeared in various languages. Scarpa in 1801 published a treatise on Diseases of the Eyes which was translated and for many years continued to be used as a text-book.

Ophthalmology in Great Britain During the First Half of the Nineteenth Century.

To John Saunders belongs the credit of having founded (in 1804) the Royal London (Moorfields) Ophthalmic Hospital. It was he who first recommended operating for congenital cataract, pointing out the great advantages of its early performance.

In 1817 a course of lectures on the anatomy and diseases of the eye was given by George Guthrie, who accompanied Wellington on all his campaigns. In 1823 he published *"Lectures on the Operative Surgery of the Eye,'* probably the first work in English to deal accurately with those diseases of the eye that require operative interference.

A colleague of Guthrie in the Westminster Hospital was the eminent James Wardrop, who performed enucleation in sympathetic ophthalmitis and wrote an essay on the pathology of the human eye as early as 1808.

Among other representative British ophthalmologists may be mentioned Tyrrell, a nephew and pupil of Sir Astley Cooper; Sir William Lawrence, who wrote able treatises on the medical and operative treatment of diseases of the eye; Benjamin Gibson, who recommended linear extraction of cataract in 1807 and demonstrated the rôle of the vaginal secretions in the production of ophthalmia neonatorum; John Vetch, who described Egyptian ophthalmia (to which the Danish physician Bendz subsequently gave the name trachoma); and we may say that to Bowman we owe the scientific treatment of lachrymal diseases.

German Ophthalmic Surgeons in the Beginning of the Nineteenth Century.

In Germany a large number of eminent ophthalmologists were aiding in the advancement of this science by patient observation and research. Among these were Jüngken, a colleague of the elder von Graefe and Rust; von Ammon, celebrated for his labors in the pathological anatomy of the eye; while the works of Rosas and Arlt, and the journals of Graefe and Walther, laid the foundation of ophthalmic literature. In 1838 George Stromeyer, of Hanover, recommended the operation of tenotomy for strabismus, which was first performed, on his recommendation, by Dieffenbach in 1839.

Nineteenth Century Ophthalmic Surgeons in France.

Bonnet enucleated the eyeball without removal of the ocular

muscles in 1842, an operation first performed by Ferrall, of Dublin. Sichel, a scion of the Vienna school, in 1848 published his *Leçons cliniques sur les lunettes*, while the familiar names of Carron du Villars and Louis Desmarres belong in part at least to the pre-ophthalmoscopic period.

Ophthalmic Surgery in America.

In this era, we find the beginning of ophthalmology in America, as well as indications of the separation of operative ophthalmology from general surgery, early manifested by the foundations of the New York Eye and Ear Infirmary in 1820; the Pennsylvania Infirmary for Diseases of the Eye and Ear in 1822; the Massachusetts Eye and Ear Infirmary in 1829 and Wills Ophthalmic Hospital in 1834. George Frick, of Maryland, published in 1824 *A Treatise on Diseases of the Eye, including Doctrines and Practice of the most Eminent Surgeons and particularly of Professor Beer.* He was the first independent writer on ophthalmology in the United States.

As early as 1826 Edward Delafield delivered a course of lectures on diseases of the eye, using the New York Eye and Ear Infirmary for clinical instruction. Isaac Hays, of Philadelphia, in 1843 edited and made many corrections in and additions to Sir William Lawrence's *"Treatise on Diseases of the Eye."* He was an early investigator of color-blindness and astigmatism. In 1841 John Dix, of Boston, wrote on the subject of strabismus, while James Bolton, of Richmond, Virginia, published in 1842 *A Treatise on Strabismus with a Description of New Instruments,* etc.

The Invention of the Ophthalmoscope.

The pre-ophthalmoscopic age now passes and we enter upon a new era with the invention, by Helmholtz, in 1851, of the ophthalmoscope, one of the simplest instruments in the world. Ophthalmology was now revolutionized and in many respects reconstructed.

The interior portion of the eye could at least be illuminated and explored. It is said that the observation of the reddening of the pupil in a drowning cat first suggested the invention to Méry in 1704. The normal and abnormal appearances of the deeper structures of the eye, as seen with the ophthalmoscope, were, soon after its invention, made the subject of works by Jaeger, Ruete and Pilz, in Germany; Follin and Sichel, in France; Hulke, Bader and Hogg, in England.

In considering this most important aid to the diagnosis of diseases of the inner parts of the eye we must mention the employment of oblique illumination by Liebreich in 1855, though it had been recommended by Himly in 1805.

In the nineteen years that intervene between the invention of the

ophthalmoscope in 1851 to his premature death in 1870 Albrecht von Graefe was master of his art. The discovery (in 1856) of iridectomy for glaucoma would alone have perpetuated his fame, but it is equally secure through his application of the ophthalmoscope to the study of ocular diseases.

The foundation of modern ophthalmology is largely von Graefe's handiwork. To him we owe the operation of linear extraction, as well

Fig. 16.
Hermann von Helmholtz.

as most valuable observations on almost every subject connected with ophthalmology; but greatest of all is the cure of glaucoma by iridectomy.

The invention of the ophthalmoscope by Helmholtz was soon followed by his ophthalmometer. Prior to the discovery of the latter in-

strument no definite means existed for measuring the corneal curvatures. Little was known about the refraction and accommodation of

Fig. 17.
F. C. Donders.

the eye until the calculations and studies of Donders. It remained for him to place physiologic optics on a scientific basis.

The work of Donders suggests the test-types of Jäger and Snellen, as well as the methods of retinoscopy suggested by Bowman and rediscovered by Cuignet in 1873.

This short sketch will serve to bring the development and progress of ophthalmology to within the knowledge of most men; and there have been and are so many names distinguished in this branch of medicine since the death of von Graefe that we cannot attribute to each his proper share in the general improvement. Their efforts have been directed, with the help of improved ophthalmoscopes and other means, to the diagnosis of constitutional diseases from the changes observed in the interior of the eye; to an improved therapy, as seen in the use of such agents as eserine, cocaine and other drugs; to the pathology of glaucoma and newer operations as a substitute for iridectomy; to the bacteriology of the eye; to the perfection of operations for cataract and, finally, to the development of the literary side of ophthalmology. Doubtless in future years the ophthalmology of the present will appear as crude and unsatisfactory to our successors as the early views are to us; but "we are not to stand still lest we go backwards," as the old German proverb puts it.

PART II.

THE FORENSIC RELATIONS OF OPHTHALMIC SURGERY.

By THOMAS HALL SHASTID, A. M., M. D., LL.B., Marion, Ill.

Court Systems and Basic Legal Principles in America, England, France, Germany and Italy—Ophthalmic Expert Testimony—Legal Considerations in the Countries Named—Surgical Considerations—Commonest Injuries with which the Ophthalmo-Surgical Expert has to Deal—Simulation and the Tests Therefor—False Attribution of Injuries and Diseases, and the Various Tests for that Subtle Form of Falsification—Exaggeration and the Tests Therefor—Dissimulation and Cautions—Visual Economics—Questions of a General Nature Relating to the Power of Vision and the Condition of the Eye After Death and During Sleep—Ocular Indications of Poisoning, Burning, Suffocation, Strangulation, and Hanging—Ocular Signs of Identity—Ophthalmo-Sanitary Legislation in America, England, France, Germany and Italy—Malpractice—Legal Considerations of the Various Countries—Surgical Considerations—Typical and Otherwise Interesting Ophthalmic Cases which Have Been the Subject of Suits Either Actual or Contemplated.

I.

COURT SYSTEMS AND BASIC LEGAL PRINCIPLES IN AMERICA, ENGLAND, FRANCE, GERMANY AND ITALY.

Introductory.

In order to comprehend the laws relating to medical experts, the laws on which the science of visual economics and the like depends, and especially the laws relating to medical and surgical malpractice, either in this or in any other land, it is first of all essential to comprehend the system of courts in the countries whose laws are under consideration, and also certain fundamental legal principles, without a knowledge of which no individual laws whatever can be really understood. Nor is this task so formidable as it might at first appear. Comparative jurisprudence, though a realm of almost infinite extent[1], nevertheless exhibits for its prominent characteristics certain very simple

[1] So vast, in fact, is the field of comparative law, that only a little (to speak relatively) has ever been done to develop it.

matters, which can easily be stated and easily be understood. And only these featural affairs, these salient characteristics, will here be attempted.

COURT SYSTEMS AND BASIC LEGAL PRINCIPLES IN THE UNITED STATES.

To take our own country first, because it is the nearest and because its judicial system, though the most difficult, is already partly known to us. In the United States two entirely distinct judicial systems are daily operating, as it were side by side—the federal and the state. The federal courts exist by the authority of the federal constitution—the constitution of the United States of America—and the state courts by the authority of the constitutions of the various separate states—Texas, New York, Illinois, etc. The federal courts interpret, apply, and enforce the constitution of the United States, the statutes which have been passed by Congress, and the various judicial decisions which have been rendered in former cases by these same federal courts. State courts, on the other hand, interpret, apply, and enforce their own constitutions, the statutes of their own legislatures, and the various judicial decisions which have been rendered in former cases by themselves.

Now, exactly what courts are those which go to constitute the so-called "federal" system, and what, in the case of each, is its jurisdiction? The federal courts consist (excluding certain tribunals whose existence is here irrelevant even for purposes of clearness, such as the interstate commerce commission, the consular courts, etc.) first, of numerous district courts, then, next higher, of a number of circuit courts, then, higher still, of the circuit court of appeals, and, finally, the Supreme Court of the United States.

The federal *district courts*[2] have original jurisdiction only, no appellate. Their authority extends (as well as to many other matters) to all cases of admiralty and maritime jurisdiction, to "all crimes not capital," and "all cases arising under the postal laws." In all of these matters, as will be readily observed, the assistance of the medical expert witness is frequently required for the untying of lego-medical knots.

The *circuit courts* (we are still speaking of the federal system) have, like the district courts, original jurisdiction only, no appellate. Their authority extends (as well as to many other matters) to "controversies between citizens of different states in which the matter in dispute exceeds, exclusive of costs, the sum or value of two thousand dollars." In these courts, therefore, the doctor may be required to ap-

[2]It may not be amiss to suggest that there are several federal district courts (no district, by the way, transgressing a state boundary) in almost every state, while several states together are always included within a single federal circuit.

pear either in his quality of expert witness or in that of defendant in a malpractice suit.

The *circuit court of appeals* has appellate jurisdiction only, but this extends to cases which originally arose in either a district court or a circuit court.

The jurisdiction of the *Supreme Court* of the United States is thus expressed by the federal constitution:[3] "In all cases affecting ambassadors, other public ministers and consuls, and those in which a state shall be a party, the Supreme Court shall have original jurisdiction, and in all other cases * * * appellate jurisdiction * * *." So far as this court possesses original jurisdiction, it may, of course, require the attendance of expert (as well as of ordinary) witnesses.

Thus much for the federal system of courts; now for the systems, or sets, of courts which exist in the separate states and which operate by virtue of the authority conferred upon them by the various state constitutions. These state systems differ a little in the different states, but, in the state of Illinois for example, they are, briefly: the coroners' courts, the courts of the justices of the peace, the county courts, the circuit courts, the appellate courts, the city courts (simply auxiliary circuit courts) and the Supreme Court.[4]

As defendant in a malpractice suit, the physician or surgeon (including, of course, the ophthalmic surgeon) may be cited to appear in the circuit court, or, indeed, if the amount sued for be small enough, in the county court.[5] If either of the parties appeals from the circuit court (in which tribunal the suit is nearly always brought) he goes to the appellate, and later, if the matter is taken still farther, to the Supreme Court.

As expert witness, the physician or surgeon (including, of course, the ophthalmic surgeon) may be summoned to the coroner's court, the court of a justice of the peace, to the circuit court, and, sometimes, to the Supreme Court, *i. e.*, in cases where this tribunal possesses original jurisdiction. He never appears, however, before the Appellate Court, because the competency of this court is limited exclusively to appeals. In the coroner's court his function is restricted to assisting the coroner's

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[3]Art. III, Sec. 2, par. 2.

[4]In New York and Kentucky the "Supreme" Court is not really supreme. In each of these states, the highest court is the Court of Appeals, while the so-called "Supreme" Court ranks next beneath.

I have not seen fit to set down in anything resembling a comprehensive manner the various jurisdictions of the different state courts, though I made an approach to this in the case of the federal system; the reason being that nearly every citizen has a fair idea of the jurisdictional field pertaining to the courts of his own state; but a hazy one indeed with respect to the competence of the courts of the United States.

[5]Only, however, in counties in which separate probate courts have been established.

jury in arriving at a verdict as to the probable cause of death.[6] In the justice's court, his office is frequently to decide as to whether a certain injury is severe or only slight, or whether it is likely to prove fatal or not; for, on matters such as these, sometimes, in criminal cases, depends the defendant's right to bail. In this court also, as well as in the county court, the medical or surgical expert not infrequently gives evidence on various other matters. In the circuit court, finally, his evidence is as wide as the broad field of medicine.

It is to the circuit court, well nigh always, that the ophthalmic surgeon is called as an expert witness.

An interesting matter presents itself at this point: What is the line of demarcation separating the jurisdiction of the federal system of courts, taken altogether, on the one hand, from that of the various state systems, or sets, of courts, taken altogether, on the other? Territorially, of course, the jurisdiction is nearly the same in each instance—state courts, to be sure, being wholly devoid of authority over the high seas, over the District of Columbia, etc.—but what about subject-matter? Just what kinds of causes, in other words, are triable in the federal system and what kinds in a state system? Says the federal constitution:[7] "The judicial power of the United States shall extend to all cases, in law and equity, arising under this constitution, the laws of the United States, and treaties made, or which shall be made, under their authority; to all cases affecting ambassadors, other public ministers or consuls; to all cases of admiralty and maritime jurisdiction; to controversies to which the United States shall be a party; to controversies between two or more states; between a state and citizens of another state, between citizens of different states, between citizens of the same state claiming lands under grants of different states, and between a state, or the citizens thereof, and foreign states, citizens, or subjects." This grant of jurisdiction by the separate states to the federal government leaves all other jurisdiction whatsoever in the hands of the separate states. The practical results, however, are just a little different from that. Says Dwyer:[8] "In fact, many cases within the reach of the judicial power of the federal government are left wholly to the state courts; in other cases the courts of the United States have

[6]The office of coroner was abolished in Massachusetts in 1877, and that of "medical examiner" created in its stead. In case the medical examiners (who must be registered physicians) decide that the death in question was due to violence, they so report to the district attorney and to a justice of the district. Similar changes have been made in Michigan, Rhode Island and Connecticut. See "The Office of Coroner," by R. B. H. Gradwohl, M. D., St. Louis, in the *Journal of the American Medical Association*, Mar. 12, 1910, Vol. LIV, No. 11, p. 842.

[7]Sec. 2, Art. III. The section is given here in full, though partly irrelevant otherwise to present purposes, for the sake of clearness.

[8]"*Law and Procedure of U. S. Courts*," Ann Arbor, Mich., 1901, p. 63.

exclusive jurisdiction; while in others, the state courts are permitted to exercise a jurisdiction concurrent with the federal courts."

It happens, though very rarely, that actual conflict takes place between the jurisdiction of the federal and that of the state courts. What system, in such circumstances, has the actual cognizance of the particular case at bar? Here, again, the federal constitution speaks:[9] "This Constitution, and the laws of the United States which shall be made in pursuance thereof, and all treaties made, or which shall be made, under the authority of the United States, shall be the supreme law of the land; and the judges in every State shall be bound thereby, anything in the constitution or laws of any State to the contrary notwithstanding." Thus, therefore, in case of actual conflict, the federal law is supreme. *But there must be actual conflict.* Within its own proper classes of cases, the law of any state is as absolutely paramount as is that of the United States within its proper classes of cases.[10]

So much for American courts, and, briefly, the power which each of them possesses. There remains, however, a very important piece of legal machinery to be considered in connection with the most of these courts—namely, the jury. In the coroner's court, a jury—which can never be dispensed with—consists of six men. In a court of a justice of the peace there is generally no jury, but "either party may have the

[9]Art. VI., par. 2.

[10]If anyone should think these legal preliminaries to my chapter unnecessarily long, I would offer as my excuse the fact that works on legal medicine contain, as a rule, extremely little information on the important subject of courts and fundamental legal principles (these matters being continually assumed to be understood) and that, as a consequence, such information is not, as a rule, very accessible to doctors, while, as already stated, a little of such knowledge is absolutely essential to even a fair comprehension of the individual statutes and rules with regard to expert witnesses, economics, malpractice, etc. Just to illustrate in connection with the matter to which this note is appended: Not long since, a physician of excellent education and wide reading, having been threatened with a suit for malpractice in an Illinois court, had found in a widely-circulated work on legal medicine a case which had been reported by a federal court and which seemed to him to militate against his interests. He declared excitedly that, though the law in Illinois was greatly in his favor, yet that the federal law would, being higher, set aside the law of Illinois, and thus destroy his prospects in the case. He was absolutely amazed to learn that the federal decision had no authority whatever in an Illinois court, so long as the latter tribunal was acting within its jurisdiction and so long as it possessed on the point in question decisions of its own. Had it had no decision of its own, then (as will appear hereafter) the federal case would have taken on persuasive (not binding) authority, the same precisely as would the decision of any court of last resort in any judicially influential state with regard to the same question. To be sure, had the plaintiff been a citizen of another state than that in which the doctor in question had his citizenship, and had the amount involved exceeded the "sum or value" of two thousand dollars, and had the plaintiff, taking advantage of these facts, actually brought her suit in a federal court, then, and then only, would the action, being in a federal court, have been subject to federal law. One can read and re-read individual laws without the slightest actual understanding of them, unless he comprehends in advance these few, simple, fundamental matters.

cause tried by a jury if he shall so demand before the trial is entered upon, and will first pay the fees of the jurors."[11] When, in a justice's court, a trial is had by jury, the body consists (in Illinois, for example) of "six, or any greater number not exceeding twelve, as either party may desire."[12] A jury (not always had) in the county court, consists of twelve men, unless the parties elect to reduce the number to six. In the circuit court there are two kinds of juries—the grand jury and the petit jury. The grand jury is a sort of inquisitorial or provisional, tribunal, consisting of not less than twelve men or more than twenty-three, whose duty it is, in private session, to examine into various matters of a criminal nature, either on their own motion or that of a public prosecutor, and, in case they deem it proper so to do, to present to the circuit court a formal, written accusation, or "indictment." The petit jury, in a circuit court, consists of twelve men. Its duty, like that of a jury in any other court, is, generally speaking, to decide upon the facts, while the function of the judge is, speaking generally again, to determine points of law. In the circuit court, a trial is almost always had by jury (except in chancery cases, and sometimes even then). The decision of a jury is called a "verdict." The conclusion of the judge (which, in a jury trial, is of course based upon the verdict) is known as the "judgment." In any petit jury, a unanimous vote is absolutely necessary to constitute a verdict, both in civil and in criminal cases. In a grand jury, a majority vote is sufficient if it amounts to twelve.

Trial by jury is a normal, and a very important, part of that great division of the legal systems of civilized countries which is known as the Common Law—*i. e.,* the legal systems of England, and the various lands—Australia, Canada, the United States, etc.—that have taken their basic legal views from that country. It is not normally a constituent of the other grand division, or class, of legal systems—*i. e.,* those derived from the civil (Ancient Roman) law, and to which belong the legal systems of practically all the countries of continental Europe.[13] However, as we shall later observe, the jury has, to some extent, owing to the influence of the English Legal System on the Continental Systems, been introduced into the judicial machinery of Germany, France, Italy, and even of some other continental lands.

The importance of this little body of often illiterate men, for the

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[11]Hurd's "*Revised Statutes*" *of Illinois*, 1909, Chap. 79, Sec. 48.

[12]Loc. cit.

[13]One of the most remarkable facts of human history is this strange, this well-nigh inexplicable vitality of the ancient Roman law. That a system of jurisprudence developed in a state of society in every way so different from that of modern Europe, should persist through all the centuries and be found still applicable, is an almost miraculous occurrence. But the Romans seem to have constructed their jurisprudence as they did their roads—to last forever.

parties, for the judges, and for expert witnesses, can hardly be exaggerated. In common law countries, for example, in which the jury trial is so conspicuous a feature, it has given rise to an extensive and complicated branch of the law, which is known as the Law of Evidence—a body of rules relating to what may, and what may not, be presented to the jury. This great branch of the law, it would seem, does not possess an independent existence (or none worth mentioning) in any of the civil law countries. On the jury it is, almost always, that the medical expert witness is required to shed his scientific light. To the jury it is, moreover, that, when a doctor appears as defendant in a suit for medical or surgical malpractice, his case is practically handed over for its entire decision. Indeed in Illinois, and, I believe, in certain other of the American States, the jury is made, for weal or for woe, sole arbiter not only of the facts but of the law.[14]

Great, therefore, is the jury in the various Common Law Systems. Of little importance, however, is that body of men in the systems which have descended from the jurisprudence of ancient Rome. The duties of a medical expert witness, accordingly, are somewhat different in common law, from what they are in civil law, countries.[15] In the former, for instance, the functionary in question addresses the jury, in the latter, the judge. In a common law land, he directs his remarks (generally speaking) to a body of mentally untrained men, incapable, wholly, of complex reasoning, or, in other words, of winnowing testimony, for themselves, and hence he is bound to submit to a multitude of rules respecting what is, and what is not, "proper to go before the jury." In a civil law land, on the other hand, he addresses the judge, or it may possibly be a benchful of judges, who are nearly always highly trained logicians, and, for that reason, he is wholly unhampered by our truly astounding "rules of evidence."

Now, what kinds of law do American courts—acting, to be sure, very often in conjunction with their juries—interpret, apply, and enforce? and, moreover, what are the rules, or principles, according to which are made these interpretations, these applications, these enforcements?

We have already seen that, in the federal courts, the laws applied are, chiefly: the federal constitution, the acts of Congress, and, finally, the decisions of these same courts in former cases;[16] and, further, that

[14]Under instructions from the judge, of course.

[15]A fact too often lost sight of by those who propose reforms in the medical expert systems of the United States—reforms suggested, in very many instances, by the successful operation of medical expert corps to be found, here and there, among civil law countries (France and Germany, for instance, not Italy.)

[16]It should, of course, be understood that, in any jurisdiction, it is only the decisions of "courts of last resort" that are really regarded as law for

in a state court-system, they are: the constitution of the particular state in question, the statutes passed by the legislature of that state, and, finally, the decisions of these same courts in former cases. Now, in each instance—either in the federal system or in any given state system—the question, of course, arises: which of these kinds of law is of the higher force and effect? in other words, when a conflict arises betwixt constitution, statutes, and case-law (otherwise known as the common law, the judge-made law, and the unwritten[17] law) which kind of law is held to supercede the other kinds—constitutional law, statutory enactments, or the "common," or "unwritten," or "case" law? The invariable rule is, whether in any state system or in the federal system, that the common, or case, law is the lowest form of law, and must give way, in case of conflict, to statutory enactment, and that both statutory enactment and case-law are controlled by the constitution. Of course, multitudes of decisions accumulate, in the course of the application of statutes and of constitution, and these decisions become, as it were, a part—and a very important part—of the constitution or of the particular statute which is under consideration. They, too, are a part of the law.

Again, certain rules exist for the application of case-law, or common law, at least some of which must be understood before the "legal relations" of anything whatever can be even slightly comprehended. The most important of these rules are:

1. A case of "first impression"—*i. e.,* a pioneer case or a case which, for the first time in a court of last resort in the given jurisdiction brings up directly for decision the matter in question, does not possess so binding a force as law as do subsequent cases holding to the same effect; and, in general,

2. An old case, if other things are equal, does not possess so high an authority as one more recent.

3. Whatever is said in a case that is not strictly necessary to the decision of that case, does not take on the force of law for subsequent cases, but is only *obiter dicta*—*i. e.,* "sayings by the way."

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subsequent cases. In the federal system, the "court of last resort" is generally the Supreme Court of the U. S., but, in some matters, the Court of Appeals possesses the power of uttering the final word. The doctrine that the decisions of courts of last resort take on the force of law for subsequent cases in courts of any grade, is known as the doctrine of *stare decisis* (to stand, or abide, by decided cases). This doctrine prevails in England and in all the various countries which have derived their legal system from that land—Canada, the U. S., etc. In civil law countries (*i. e.*, countries whose legal principles were, as already stated, adopted chiefly from the ancient Romans—as France, Germany, Italy) the doctrine does not prevail. A judge may, if choose, in these countries, apply the law in one way today and in another way to-morrow.

[17]Because, originally, in ancient times in England, the decisions of courts were neither printed nor written, but merely preserved in men's memories.

4. The decision of a court of last resort in any other state than that in which a case arises, has no compulsory force as law, but "persuasive authority" only—an authority which, moreover, is greater or less according (among other matters) to the eminence of the court of last resort which rendered the decision applied to. Thus, the decisions of the Supreme Court, still more the Court of Appeal, of the State of New York have always been possessed of much "persuasive authority" in the courts of other states. The same is true of the Supreme Court of New Hampshire, and of some other states.

5. A scanty, ill-reasoned opinion is of less force than a full and cogent one.

Two great divisions of the law of any country, which are absolutely necessary to be understood, may here most conveniently be discussed, though with special reference to American law—the *criminal law* and the *civil*[18] *law*.

The *criminal law* is that division of the law which relates to crimes, and a *crime* is any act or omission regarded by the legislative power as being so injurious to the general public that the government itself will punish the person or persons who are shown to be responsible for such act or omission. Any proceeding which has for its object the infliction of this punishment is called a *criminal action*, or, more briefly, a *prosecution*. Crimes are of three grades, *misdemeanors, felonies*, and *capital crimes*. A *misdemeanor* is any crime inferior to a felony. A *felony* is a crime punishable by imprisonment in the penitentiary. A *capital offense* is any offense punishable by death.[19]

The *civil law* is simply the non-criminal portion of the law.

In criminal actions, or prosecutions, physicians are not infrequently summoned as expert witnesses, to assist in the unravelling of various medical or surgical tangles, especially in connection with the offenses specifically known as murder, rape, mayhem (mutilation), etc. In actions of this sort, however, the ophthalmic surgeon is naturally enough very seldom asked to lend to the jury the assistance of his

[18]The term, "civil law," it is well enough to notice here, is employed in this chapter, as elsewhere in legal writings, in two widely differing senses. In the first acceptation it denotes the various legal systems descended from the *corpus juris civilis* of Ancient Rome—as those of France, Germany and Italy. In the other sense, it signifies the *non-criminal* portion of the law of any country.

[19]Various definitions of some of these terms prevail in various jurisdictions, the consequence of which is confusion. The chief differences occur with regard to the word *misdemeanor*. The definitions above given are the simplest, and, possibly, as correct as any that could be stated for a general understanding. They are, moreover, those recognized by the present-day law of England. Thus, Russell, "*Law of Crimes*," 1910, page 10: "The word *misdemeanor* is applied to all offenses (whether at common law or by statute) which are below the degree of felony, whether they are punishable on indictment or on summary conviction."

knowledge and skill. It is the general practitioner that is almost always appealed to. In civil cases, however, especially in that variety known as personal injury suits (including, of course, the sub-variety known as malpractice actions) the ophthalmic surgeon is frequently subpœnaed to explain to the jury the nature of various injuries to the eye, or diseases of that organ, or of the probable extent and economic value of the disability produced by such diseases and injuries.

In connection with this matter of personal injury actions, we have to remark that these are brought invariably for the purpose of securing what is technically known as "damages"—*i. e., monetary compensation* for a damage—and that damages are of three very simple classes, or varieties: *nominal* damages, *compensatory* or *substantial* damages, and *punitive, vindictive,* or *exemplary* damages.

Nominal damages are awarded when there is a mere technical violation of a right, but no actual damage. The amount of nominal damages awarded in any given case is often very small—six cents, sometimes one cent. Such a judgment, however, throws, as a rule, the costs of the suit upon the defendant. On the other hand, in certain jurisdictions a judgment, to "carry costs," must be for "substantial" damages.

Substantial or *compensatory* damages are allowed when there is not merely a technical violation of a right, but also an actual damage, or injury. In the estimate of such damages, matters such as the following may be taken into consideration: (1) Necessary and reasonable expenses, as hospital fees, nurses' and doctors' bills; (2) loss of time; (3) pain and suffering; (4) disfigurement; (5) reduction of the earning capacity. It not infrequently happens that this last-named item constitutes by far the most important feature of the bill; hence the significance which attaches to the subject of "Visual Economics"[20]—*i. e.,* the methods whereby can be correctly estimated the loss of earning power directly[21] consequent on the various injuries and diseases of the eye.

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[20]To be treated some distance *infra.*

[21]It may not be amiss to state explicitly that any damage, in order to constitute a ground for a suit for damages, must be a direct, not an indirect, result of the wrongful act, or, as it is often expressed, the result of a proximate, not a remote, cause. To express the matter still differently, "the damage must be the legitimate sequence of the thing amiss." An excellent example of this principle is furnished by the leading case of Scott v. Shepherd, in which it appeared that the defendant had thrown into a crowd a lighted squib. One after another of those in the crowd struck at the squib, to keep it from impinging on their faces, until, at last, "it had burnt out the plaintiff's eye." The defendant pleaded that the damage was indirect, insomuch as it was really due to "the subsequent acts of others." But the court held that the acts of the others were "instinctive and innocent," and such as should have been foreseen by ordinary forecast, and that the act of the plaintiff, therefore, was the direct cause of the damage.

Punitive, exemplary, or *vindictive* damages, may be recovered—in certain jurisdictions only, and these not many—when the damage was inflicted under aggravating circumstances. This kind of damages exceeds the allowance which could be made for mere compensation, adding, as it does, thereto, a larger or smaller sum by way of punishment, or vengeance, in order, as it were, to make an example of the defendant.

These various sorts of damages can thus be briefly illustrated: A commits an assault and battery on B, but without inflicting on him any material damage. B sues A, and is simply awarded a cent in recognition of his right to freedom from assault and battery. In some jurisdictions, B, under these circumstances, would have to pay the costs of the suit, as well as the one-cent damages; while, in others, the costs would have to be borne by A.

Now, suppose that A has inflicted on B a very material injury; has, for example, knocked out one of his eyes. B can recover substantial damages, the amount to be determined by adding together the various estimated values of such items as pain and suffering, doctors' bills, loss of earning capacity, etc., as heretofore stated.

But, once more, suppose that A put out the eye of B under especially exasperating circumstances; for instance, with the declaration that he destroyed the sight of the eye merely in order to render B incapable of earning a living, or of marrying a certain person, or "simply to see what the inside of it looked like." Here, in a few (a very few) jurisdictions, the defendant would be entitled to damages in excess of those which could be considered as legal compensation.[22]

Excessive damages. This is still another term which we need to understand. The amount of damages which a jury has a right to assess is not unlimited, and, in case it assesses, or estimates, the amount at an unreasonably high figure, the damages are said to be "excessive." There is indeed no fixed rule (excepting only after "death produced by wrongful act," when the amount is usually fixed by statute either at $5,000 or $10,000); but, in case the trial judge deems the amount excessive, he has power to reduce the amount or to set the verdict aside. Higher courts, too, may declare the damages "excessive."

Thus much for the courts of the United States, including the juries thereof, as well as also certain important legal principles and definitions. Let us now consider these same matters, though much more briefly, with regard to other lands. And, first, as to the

[22]A would, of course, be liable to a criminal prosecution for mayhem (mutilation) in any jurisdiction, under the circumstances mentioned. We are speaking here only of the civil action which may always be instituted by the defendant, or his representatives (guardian, executor, or administrator) on the same set of facts as the criminal action.

COURTS OF ENGLAND.

In that country, the fundamental legal principles are much the same as in America. Indeed, as suggested already, these principles were really adopted by the United States in an early day from the mother nation. In England, for instance, the doctrine of *stare decisis* or of case-law, prevails exactly as it does with us, and case-law there is subject to the same identical rules of interpretation as it is in America. The jury system, too, in that country, plays a highly important part, exactly as it does in this country. The English Court-System, however, is very different from ours. For one thing, there is lacking, in England, the two-fold idea—federal and state—which makes the law of America so difficult. There is only one system, or series, of courts in England. Then, again, in England there is no written constitution; and, furthermore, questions of constitutionality are decided in that country by the legislative body—Parliament—at the time when a given law is enacted. The courts have nothing whatever to do with such questions. When, in England, a law is once passed, it is law.

The system of English courts, much simplified[23] to be sure, for general presentation, is as follows:

Coroners' Courts.—The jurisdiction is a little wider than with us. It extends to deaths and fires (where questions arise as to cause) and treasure trove.

Courts of the Justices of the Peace.—The jurisdiction, as with us, extends only to certain subordinate matters.

County Courts.—Jurisdiction extends to subject-matter whereof the value involved does not exceed £100.

Courts of Session.—Criminal cases only.

Court of Criminal Appeal.—Criminal appeals only.

The High Court of Justice.—Consists of the Chancery Division, the King's Bench Division, and the Probate, Divorce, and Admiralty Division.

Court of Appeal.—Hears all appeals from the High Court of Justice.

The High Court of Justice and the Court of Appeal are, together, called "The Supreme Court of Judicature."

The House of Lords.—Does not consist of all the members of the House of Lords, but of "The Law Lords" only. Hears appeals from the Court of Appeal, and has original jurisdiction in certain classes of cases, not necessary here to be specified.

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[23]Neither in the case of the English court-system nor in that of any other court-system, do I attempt to furnish a scientific exposition of the jurisdiction of the various tribunals named; I merely endeavor to convey a somewhat general idea of the court-organization of the various nations in question.

There is only one Supreme Court of Judicature. England, however, is divided into seven Supreme Court Circuits, and the various judges of the Court apportion the work among themselves according to certain rules, and also in obedience to the ever-changing demands made upon this court by the various circuits.

Cases relating to the unprofessional conduct of physicians fall entirely within the jurisdiction of the General Medical Council—an exclusively medical body which removes the offender's name from the Register, *(i. e.,* disqualifies him from practice) in case the offense is proved. The decision of this tribunal is absolutely final.

Suits for medical or surgical malpractice are brought either in the King's Bench or the County Court, according to the amount involved. An appeal lies, first, to the Court of Appeal; then to the House of Lords.

Medical expert testimony may be required in all these courts, excepting only the Court of Appeal, which, possessing appellate jurisdiction only, does not take testimony, either common or expert.

COURT SYSTEMS IN FRANCE.

In France the doctrine of *stare decisis* does not prevail. A judge may, if he choose, decide in one way to-day and in another way to-morrow, on exactly similar states of fact. Neither do ministerial edicts have the force of law in France, contrary to the generally received opinion on that point in this country. They are supposed only to interpret the law, though instances of encroachment have undoubtedly occured. Constitution, codes and statutes—these are the three constituents of French law.

In France, furthermore, the jury system is conspicuous by its almost absence. In fact, no jury is ever employed in France, except in criminal cases, and then only in the Assize Courts, tribunals which deal, generally speaking, only with the very highest classes of crimes.[24] A jury in civil cases is unheard of. There are, in France, few technical "Rules of Evidence," no perplexing problems with respect to relevancy, materiality, or competency. The mile-long "hypothetical question" never disturbs the intellectual serenity of the medical expert, who merely hands in his report, or discusses, in a gentlemanly fashion, various matters, relevant to the issue of course, with a learned and urbane judge.[25]

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[24]Even the Assize Court jury could be adopted only during the Revolution, in 1790.

[25]Neither is there in France a Grand Jury. The functions of this exclusively Common Law body are performed in France by a special officer known as the "Juge d'Instruction," a kind of Grand Inquisitor who is entitled to examine "not only the witnesses, but the prisoner himself in absolute privacy." True, there is a "*Chambre des mises en accusation,*" which works

The defendant, moreover, in a suit for medical malpractice (which kind of suit, by the way, for reasons to appear hereafter, is extremely rare in France)[26] does not direct a mutilated defense to a body of men who may, or may not, comprehend the nature of the scientific questions involved. On the contrary, he addresses a connected exculpation to a judge (or, it may be, to a benchful of judges) who are ably assisted by official physicians, selected either by the parties or by the court but from a list drawn up at stated intervals by the Court of Appeal in the particular judicial district in which the case is heard. Surely it would not be injudicial to say that they do "order these things better in France."

The court-system of France is as follows:

Civil Courts.

a. Courts of Exceptional Jurisdiction (those whose jurisdiction is delimited by statute).

1. *Courts of the Justices of the Peace.*—Jurisdiction up to 600 francs.

2. *Commercial Courts.*—Certain commercial cases only.

b. Courts of Ordinary Jurisdiction.

1. *The Civil Tribunal of First Instance.*—There is one of these for each arrondissement, France, as is well known, being divided into a number of "departements," or states, each of these being subdivided into three or four "arrondissements."

This tribunal is of great importance in connection with the matter of medical expert witnesses, for to it belongs the power, and on it devolves the duty, to construct each year a list of qualified physicians from which the official corps of "medical experts before the courts" may later be chosen. (See Court of Appeal, *infra).*

2. *The Courts of Appeal.*—There is one of these for each of the twenty-six appellate districts, each appellate district comprising a number of "departements."

These courts are of great importance in connection with the matter of "medical experts before the courts," for this court is the body which possesses the power to appoint, and on which devolves the duty to appoint, from a list proposed, as before stated, by the Civil Tribunal of First Instance, the corps of medical experts.

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in connection with the Court of Assizes, and which is something like our Grand Jury. Nevertheless, its members are not laymen, but judges from the Courts of Appeal. The resemblance, therefore, to our Grand Jury is very superficial.

[26]Everywhere, indeed, in foreign countries, malpractice suits are far less common than among us. So far as I am able to judge, there have been more malpractice cases in the last hundred years in the United States alone than in all continental Europe.

3. *The Court of Cassation.*—One for all France. Sits in Paris. A court of error only. It never retries the facts, a retrial, if ordered, being referred back to a Court of Appeal other than that which heard the case before.

Criminal Courts.[27]

1. *Tribunal of Simple Police.*—Petit offenses only. Merely the criminal side of the Justice of the Peace's Court.

2. *Correctional Courts.*—All offenses involving a penalty exceeding five days' imprisonment and fifteen francs fine, except such as are reserved for the courts of the third degree, which are the Assize Courts.

3. *The Assize Courts.*—The highest classes of crimes only. The only court in France in which there is a jury.

Medical expert testimony is heard in every court of France.

A suit for malpractice against a physician would be begun in the Civil Court of First Instance, and the Court of Appeal of the same district would have appellate jurisdiction.

COURT SYSTEMS OF GERMANY.

In Germany, as in France, the doctrine of *stare decisis* (case-law) does not, theoretically at least, prevail. In actual practice, however, the decision of a court of last resort in the German Empire is given great weight in subsequent similar cases, and is almost always adhered to. Says Schuster:[28] "Theoretically the rule of English law, according to which the judgment of any Court establishing any rule of law is conclusive for all subordinate and co-ordinate Courts, is not accepted in Germany, and any young 'assessor' fresh from his final examination may overrule the judgment of the Imperial Supreme Court, but in practice the ruling of any Superior Court is of the greatest weight and authority. * * *" The authority of legal text-books, too, in German courts, is probably higher than in any other country. Constitution, codes and statutes, however, are, in Germany, as in all other Civil Law countries, of absolutely binding power.

The system of courts in Germany is somewhat peculiar. It is not so simple, quite, as is the system of France (which, in fact, is almost like the simple series of one of our single states) nor, on the other hand, is it quite so complicated as the American state-and-federal plan. It holds, in fact, a position midway between these two systems—the extremely simple system of France and the extremely complex system of America. The highest court in Germany, to be explicit, is a federal

[27]Nothing at all like our Coroners' Courts exists in France, Germany, or Italy.

[28]"The Principles of German Civil Law," by Ernest J. Schuster, Oxford, 1907, p. 12.

court (the *Reichsgericht)* and all the other courts are state courts (courts of the *Bundesstaaten).* The situation is much as if, in America, the Supreme Courts of all the states were abolished, then all the federal courts, except the Supreme Court, were done away with, and, finally, the federal Supreme Court was placed at the head of all the forty-eight state court-systems. Even then, however, we should be embarrassed by forty-eight different kinds of procedure employed in the forty-eight different state court-systems, whereas, in Germany, although the state courts are without exception supplied by the separate states *(Bundesstaaten)* the legal procedure, throughout, is absolutely uniform, being federal.

The courts of Germany are as follows:

For Civil Cases.

Amstgerichte.—Suits involving property rights not exceeding in value the sum of 300 marks ($70.00), and certain other matters requiring expedition, without regard to the amount of the claim.

Landgerichte.—Original jurisdiction in all other civil matters and appellate jurisdiction from the *Amstgerichte.*

Oberlandesgerichte.—Appellate jurisdiction from the *Amtsgerichte.*

Reichsgericht.—The imperial court: the highest court in the German empire. Sits in Leipzig. Appellate jurisdiction from the *Oberlandesgerichte.*

For Criminal Cases.

Schöffengerichte.—Simply the penal side of the Amtsgerichte. One judge and two laymen (or *Schöffen).* Competent for all *"Ubertretungen"* for the so-called *"Antragsvergehen"* and for those "Vergehen" punishable at the most with three months in jail or a fine of 600 marks ($140.00).

Landgerichte.—Penal Chamber thereof. For all other "Vergehen" and also for "Verbrechen" which are punished at most with five years in the house of correction, and for the "Verbrechen" of juvenile persons.

Appellate jurisdiction over Schöffengerichte.

Schwurgerichte.—Three judges and twelve jurymen (Geschworene). "Verbrechen" which do not fall within the jurisdiction of the Penal Chamber of the *Landgericht* or of the *Reichsgericht.*

Oberlandesgerichte.—Sit in appeal from judgments of the Penal Chamber of the Landgericht which the chamber heard on appeal, and in first instance cases from that chamber where the revision is grounded exclusively upon some legal rule contained in the Landesgesetzen.

Reichsgericht.—Penal Chamber thereof. Appeals from Schwurgerichte and from the Penal Chamber of the Landegerichte in cases in which that chamber had had original jurisdiction.

Original and final jurisdiction in treason and high treason against Kaiser and Kingdom.

The court in which a civil suit for malpractice would be brought, would be in the Landgericht. An appeal would lie to the *Oberlandesgericht* and, thence, to the *Reichsgericht.* The functions of a medical court-expert in Germany are pretty well indicated by the jurisdictions of the different courts. The peculiar hierarchy of medical officials in Germany will be explained later.

THE ITALIAN COURTS.

The fundamental legal views of Italy are much the same as those of France. Judicial decisions *(giurisprudenza)* have, as in France, no force at all as law—except as "persuasive authority"—still, contrary to the case in France, ministerial edicts do possess binding authority. The system of courts in the two countries is very similar. Thus, in Italy:

For Civil Cases.

Judici di Conciliatori.—Jurisdiction up to 100 francs.

Pretore.—Jurisdiction up to 1,500 francs.

Tribunale.—Original jurisdiction in all claims of over 1,500 francs, and appellate jurisdiction in certain cases from the pretore.

Appello.—Court of Appeals. Hears appeals from the tribunale.

Cassazione.—Highest court in Italy. Jurisdiction where error has been committed on either side.

For Criminal Cases.

Pretore.—Petit cases.

Tribunale.—The penal chamber thereof.

Corte d'Assise.—Where the crime is punishable by not less than five years imprisonment. Tries by jury, the assize court being, as in France, the only tribunal which acts in conjunction with a jury. No appeal.

A civil suit for malpractice would be begun either in one of the pretorian courts or in one of the tribunale, according to the amount of the demand. A marked peculiarity, however, of the Italian law, is that a judgment for damages cannot be secured against a physician until a criminal prosecution has first been brought against him, and successfully, on the same state of facts.

There is no corps of "official expert witnesses before the courts" in Italy. The medical expert system is, in fact, almost the same in Italy as it is in Common Law countries.

We have now reviewed, in a very brief manner, the court-systems and fundamental legal principles of the various lands proposed to be considered in this chapter—America, England, France, Germany, and Italy—systems and principles which, to some degree, must be kept in mind, if the remaining (and more particular) portions of this chapter are to be really comprehended.

And, first, among these more particular matters, is that of

II

OPHTHALMIC EXPERT TESTIMONY.

A.—LEGAL CONSIDERATIONS.

Legal Considerations Regarding Ophthalmic Expert Testimony in the United States.

In America, as in every civilized country, witnesses are, from the nature of the testimony which they give, divided into two very sharply differentiated classes—ordinary witnesses and expert witnesses. The former class simply testify to facts, the latter—the expert—to opinions that are founded upon facts, either actual or assumed. Says Hutchins:[29] "Ordinarily it is the province of the jury to consider the facts in the case, and, uninfluenced by the opinions of witnesses, draw such inferences therefrom as their judgment may dictate. But in cases involving questions outside of the ordinary range of inquiry, in which correct conclusions can be drawn from the facts only by means of scientific deductions, it is apparent that most jurors would be unable to perform the functions that the law imposes upon them, unless aided in their deliberations by the judgment and opinions of witnesses skilled and experienced in the subject under investigation." From this it readily appears that the expert witness is really an interpreter of the facts. He stands to the jury (or, in some instances and lands, the judge) in much the same relation as a linguistic interpreter does in the case of a witness who cannot speak the language of the court in question, or of a witness who is deaf and dumb. He tells the jury or the judge the real meaning and import of the facts adduced by the ordinary witnesses—a meaning and an import which the judge or the jury could not, presumably, extract from these facts themselves, by reason of their lack of special education with regard to the matter in question.

An expert witness may be a carpenter, a miner, a railroad man or a chemist, a lawyer[30] or a dealer in silks; in very many cases he happens to be a druggist, a dentist, or a doctor: in every case, however, he

[29]Hutchins.—"The Physician as an Expert, "*Michigan Law Review*, Apr. 1904, Vol. II, No. 7, p. 601.

[30]See the next succeeding footnote.

is called upon to aid the jury or the judge to interpret ordinary facts by means of the expert, unordinary, knowledge which he possesses. Here, of course, we shall treat of these matters with especial reference to the needs of the doctor, and with more especial reference still to those of the ophthalmic surgeon.

First of all, however, it is well enough to understand that certain things are so generally known and accepted that they do not need to be proved by any kind of evidence whatever. Such matters are said, in legal parlance, to be "judicially noticed." Among such matters are: The existence and titles of sovereign powers, their flags and seals, the general customs of merchants, the movements of the astronomical bodies, legal weights and measures, matters of public history, domestic law[31], etc. All these and various other matters need not be proved. The court is presumed to know them.

Then, too, there is a kind of evidence, which does not depend on human testimony—namely that which arises from what is legally described as "autoptic proference," *i. e.*, the displaying of the thing itself. Says Wigmore:[32] "If the question is whether a man is of negro complexion, or whether a shoe is fastened by laces or by buttons, the testimony of one who has seen the man or the shoe, or the circumstance that the man's child is a negro or that a button has fallen from a shoe, can at least not be more satisfactory than the inspection of the man or the shoe in court." Thus a judge may take his watch and note "the length of a minute for the benefit of the jury," and a doctor may demonstrate the effects of an injurious substance, and a man whose eyes have been removed may, under appropriate circumstances, exhibit before the court his empty sockets.

Then, finally, there comes human testimony. This, as a matter of course, plays the star part in almost every trial.

Now, to return to our beginning point, the witnesses who render human testimony are of two great, widely differing varieties—the ordinary and the expert, the latter of which will be considered here.

In treating of expert witnesses we divide our subject thus: *Attendance in court, how secured; competency; examination and cross-examination; privileged communications; matters concerning which an expert witness may testify; manner of testifying; fees.*

The *attendance in court* of any witness is secured by the service of a writ called *subpœna ad testificandum.* The service is accomplished by showing the original and leaving a copy therof, or else a ticket containing the original in substance. In civil cases there must also be

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[31]But not foreign law. Foreign law, as hinted *supra*, must be proved by expert testimony given by those who are specially skilled in the subject.

[32]Note to Greenleaf on Evidence, 16th ed., 1899, p. 27.

made a payment, or at least a tender, of the amount required for mileage as well as for one day's attendance at the court. In criminal cases, however, the witness pays his own expenses, being afterwards reimbursed by the court in accordance with various provisions of the law.

In court, immediately after the swearing of the witness, there arises the question of his *competency*. In fact, the competency of a witness to testify as an expert must always first be shown before he is permitted to testify in his expert capacity. (Of course, the same man may be testifying both as ordinary and as expert).

Now then, what is an expert, especially a medical expert? In other words, what qualifications are necessary to constitute a man a medical or surgical expert, or to render him "competent?" This is a question of very great importance to the ophthalmic surgeon, as the merest matter of course. In the very first place we may remark that, in order to testify as a medical or surgical expert even in a case of injury to the eye, it is by no means necessary, from a legal point of view, that the witness should be an oculist or even a specialist with any sort or kind of limitation whatever on his practice—as eye and ear only, or only eye, ear, nose and throat. Nor is it necessary that he ever have made a special study of the eye. Nor is it at all essential that he be a graduate of any particular school of medical practice. Nor, further, that he be a graduate at all, or even a licensee on the ground of years of practice. Nor that he be in the active practice of his profession, or that he ever have practiced at any time. None of these matters go at all to the question of the admissibility of the evidence. Such things *(i. e.,* qualifications, greater or less) can, indeed, be shown, on examination either direct or cross, but such matters simply affect the *weight* that the jury may see fit to attach to the testimony that is rendered: they do not *bar* the testimony.

Nevertheless, certain qualifications are really necessary to constitute a man a medical or surgical expert. Now what are these qualifications? They are, in short, whatever will tend to confer upon the witness unusual knowledge or skill relating to the matter in question. Thus, in Lind v. Masonic Ass'n of Western N. Y.,[33] a nurse who had witnessed a surgical operation was permitted to testify for what disease the operation had been performed, on the ground that, for twenty-one years he had been a nurse in a hospital and had seen much general and surgical work. Thus, again, in Mason v. Fuller,[34] it was held that a woman who had had no training whatever in medicine, or indeed even in the single branch of midwifery, but who had had long experience as

[33]88 N. Y. Sup. Ct. R 287, 30 N Y. Supp. 775.
[34]45 Vt. 29.

a nurse in child-birth cases, was competent to render expert testimony as to whether the birth of a child was premature. Said the judge: "The witness, by her experience and observation, appears to have acquired knowledge of the subjects about which she was testifying that persons generally do not have." In State v. Cook,[35] it was held that a chemist and toxicologist who was not a physician and surgeon, and who had had no medical training whatever, was competent to testify as an expert concerning the effect of strychnine upon the human stomach and the system in general. In Everett v. The State,[36] it was held that a physician and surgeon who had been in active practice, but who, at the time of the trial, had been retired from professional work for some time, was sufficiently well qualified to testify as an expert. In Tullis v. Kidd,[37] it was held that a witness, to qualify as expert, need never have been engaged in active practice. Said the court: "If one asserts an ability to give correct opinions upon any art or science, from an acquaintance with the subject, acquired by observation and study, we cannot perceive on what ground he can be rejected because he has not been in the actual practice of his profession." In the same case, as it happened, a similar question of competency arose. The witness had attended a course of medical lectures, been licensed by the state, and had practised medicine for one year. Then he had abandoned medicine for the law, and had been engaged in legal practice for sixteen consecutive years. He was held to be competent as a medical expert, partly on the ground that he had never quite ceased to read medicine.

Another extremely interesting instance arose in California.[38] In this case it was held that a Catholic priest might testify as an expert in the matter of mental soundness or unsoundness. The opinion was based to some extent on the ground that the education which this clergyman had received in his school of theology, had been designed in part to fit him to examine into and decide upon such matters. Said the court: "It was a part of his collegiate education, and it was especially a matter of daily practice with him for ten years to familiarize himself with the mental condition of persons upon whom he was called to attend in his character as a priest; and it does seem to us that, from both education and experience, he was peculiarly qualified to express an opinion, as an expert, on the question of mental diseases."

[35] 17 Kan. 392.
[36] 62 Ga. 65.
[37] 12 Ala. 648, 650. The opinion as to the competency of this particular witness would seem to be *obiter dicta*. Moreover, the case is not a "recent" one, dating, as it does, to 1847. Nevertheless, it is quite within the spirit of legal holdings regarding these matters generally, and would probably be taken as law in almost any jurisdiction in the U. S., where the matter is not controlled by statute.
[38] Estate of Toomes, 54 Cal. 509.

The culminating point of interest, however, regarding this matter of medical expert competency, for the surgical oculist at least, lies in the fact that the law does not require the witness to have made a specialty, either in practice or in study, of any of the matters concerning which he is called upon to testify.[39] Thus a man who has never seen a case of glaucoma (sometimes, perhaps, who has never read a report of a case—for such men actually exist) is permitted to testify, merely from the sketchiest text-book knowledge of the subject, as to whether or not a given set of symptoms should, or should not, have been diagnosed as glaucoma, and as to whether an iridectomy therefor should or should not have been performed at all, and whether or not, in case it was performed, it was performed correctly. Perhaps even a nurse in an ophthalmic hospital would be permitted to give evidence on such matters. The absurdity (medically speaking, of course) is sufficiently manifest, but, in the eyes of the law, is entirely removed, or, rather, "remedied," by the fact that the opposing counsel is always permitted to show, on cross-examination, just how slight the expert's real expertness is. However, to one who understands even a very little of human nature (and glaucoma) this privilege of cross-examination constitutes by no means a sufficient defense against misapprehension on the part of the jury. The really inexpert expert's testimony may leave *some* sort of impression on the jury, whereas, as a matter of course, it ought not to leave any. The testimony of such an "expert" should be inadmissable.[40]

But this is not all. It is held that a specialist in diseases of the eye may not testify regarding medical or surgical matters that do not lie within his special field.[41] Says Rogers, in his admirable work on *"Expert Testimony,"* p. 101: "But one who devotes himself exclusively to one branch of his profesison, making a specialty of that, and having no practical experience beyond it, is incompetent, as a general rule, to

[39] Hathaway v. National Life Ins. Co., 48 Vt. 335, 351; State v. Reddick, 7 Kan. 143; Hastings v. Rider, 99 Mass. 622; Horton v. Greene, 64 N. C. 64; Kelly v. United States, 27 Fed. Rep. 616; s. c., 8 Cr. Law Mag. 174. In Castner v. Sliker, 33 N. J. L. 95, it is held that a physician may testify fully as to various ocular injuries, though neither oculist nor surgeon. Thus, too, Wigmore, citing seven cases, in a note to "Greenleaf on *Evidence,*" 16th ed., 1899, p. 54: "On matters in which special medical experience is necessary, the question may arise whether a general practitioner will suffice, or whether a specialist in the particular subject is necessary. The courts usually and properly repudiate the finical demand for the latter class of witnesses." The same writer, *loc. cit.:* "As to sanity, it is now universally conceded that a layman is competent to form an opinion."

[40] The following may be instructive: In a certain trial I heard a physician on the witness stand repeatedly refer to a pterygium as a "strinthium." Another "expert," preparing for another trial, spoke often of a "silk-fork" fracture of the radius. These Mrs. Partingtons of the witness-stand might very appropriately be abolished.

[41] Fairchild v. Bascomb, 35 Vt. 410.

express an opinion on a question that does not pertain to his specialty." So a specialist that has never been engaged in general practice, cannot testify regarding medical matters generally, whereas a general practitioner, who has never been engaged in special practice, or indeed in practice of any sort or variety, but who has only "studied medicine," may testify regarding matters medical, whether of a general nature or a special. Nay, further, a man who has never even studied medicine, but who has merely served as a nurse, or acted as a minister or priest, may, under certain circumstances, exercise the functions of the medical expert, either general or special.

No doubt the proper rule should be that expert testimony should be really expert; that, for instance, only internists in actual practice at the time of testifying should be permitted to testify regarding matters of internal medicine, practising surgeons regarding surgery, dermatologists regarding dermatological matters, and, similarly, in the case of oculists, aurists, and specialists of every kind. "Pantologists" do not exist, and courts should recognize the fact. Provision, of course, should be made for cases where the "best" evidence could not be obtained, as where, owing to the distance from medical centers, actual experts were not, practically at least, procurable, and where, owing to the death or disappearance of some person, a witness who had actually seen and examined that person would, though not an actual expert, necessarily testify, if any sort or kind of testimony in the matter were to be obtained at all. Some of these matters, of course, could and should be placed within the discretion of the trial court. The prevailing rule, however, should be in accordance with that general principle of evidence, which "requires the best evidence of which the case in its nature is susceptible."[42] A general practitioner cannot give the "best" evidence regarding injuries to, or diseases of, special organs.

It is only fair to add that in the state of Wisconsin a little has been done by statute[43] in the way of barring certain inexpert experts. In this state "no person practising physic or surgery, or both, shall have the right . . . to testify in a professional capacity as a physician or surgeon in any case unless he, before the twentieth day of April, 1897, received a diploma from some incorporated medical society or college, or shall since said date have received a license from the state board of medical examiners." This, as will be seen, bars the nurses, the students, the midwives, and the clergymen, but, unfortunately, does not exclude the inexpert expert who happens to

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[42]Greenleaf on *Evidence*, 16th ed., 1899, p. 170.
[43]*Wisconsin Statutes*, 1898, Vol. I, Sec. 1436.

be the proud possessor of a license or a diploma, and yet who cannot distinguish glaucoma from iritis.

Immediately upon the establishment of the "expert's" competency, follow, of course, the *direct examination* and then the *cross-examination*. By "direct examination" is meant the "examination by the counsel for the party in whose behalf he was called." Under this examination the witness may either (a) tell his story in narrative form, or (b) respond to various (and generally numerous) questions. When giving his testimony according to the latter method, the questions must not be "leading"—*i. e.,* such as suggest the answer desired. The ordinary witness, too, must confine himself strictly to facts, excluding rigidly all opinions or inferences; the expert, however, may, within certain limitations of course, give testimony as to opinions; in truth he is really an "opinion" witness.

The cross-examination is made by the opposing counsel, and its purpose, of course, is to overthrow or weaken the testimony rendered under the direct examination. In the cross-examination, leading questions are permitted. The "latitude" (*i. e.,* scope, or field, covered by the questions) allowed in the cross-examination is different in the different states. On the whole, the best rule would seem to be that a witness is subject to cross-examination on everything that is relative to the *case*. The rule most generally adopted, however, is that the cross-examination must be limited strictly to matters concerning which the witness testified under his direct examination. The whole matter of latitude, however, lies largely within the discretion of the trial judge.

All the evidence, it may be noted, in passing, must be relevant and competent. By relevant is meant "of sufficient probative value to be admissible at all."[44] By competent is intended, legally fit, regardless of the question of relevancy. One of the subordinate rules coming under the rule requiring "competency," is the so-called "best evidence" rule, by which is meant, as before stated, that a court will require to be produced "the best evidence of which the case in its nature is susceptible." Another subordinate rule, under the general rule of competency (perhaps, too, falling under that of the "best evidence") is that "hearsay evidence is not admissible." Thus, a physician, for example, may not testify that another physician had said to him that such and such an injury might very readily have caused the plaintiff's traumatic cataract. He must give his own opinion. If the opinion of the other physician be desired, then that other physician must be brought into court, there to render such opinion.

Closely connected with the subject of direct and cross-examina-

[44]Greenleaf on *Evidence*, 16th ed., 1899, p. 36.

tion, is that of *privileged communications.* Even in the earliest times in England (from which country we inherit, as before stated, most of our fundamental legal principles) certain matters have been considered inviolably sacred, and have been most carefully protected from disclosure in the courts. Such matters were called "privileged communications," and were privileged at the common law—*i. e.,* they did not require a statute for the purpose of rendering them privileged. The judges on their own initiative *decided* that they were privileged. It was "case law," or "judge law," or "common," or "unwritten" law. These privileged matters were, in general: State secrets, deliberations in the jury room, communications between counsel and client, and communications of a confidential nature between husband and wife. Communications, however, made to clergymen and doctors, however sacred in fact, were not held to be sacred, or "privileged," in law. Hence these matters are unprivileged still, even in the United States, except so far as has been provided otherwise by statute. Happily, in most of the states of this country, statutes have been enacted which, with certain appropriate limitations, protect the physician from disclosing on the witness stand, without the patient's consent, "any communication made to him by his patient with reference to any physical or supposed physical disease, or any knowledge obtained by a personal examination of any such patient."[45]

As to the *matters concerning which an expert witness may testify,* we may say that these, in a word, considered together, are about as wide as the whole broad field of medicine. Most commonly in question, however, in courts of law, are the following medical topics: Whether a given person is insane; the cause of a certain death; whether a certain disease is curable; whether a certain disease is curable without operation; what might have been the cause of a given injury; what a reasonable bill would be for certain medical or surgical services; whether a certain affection is or is not painful; the degree of reduction in earning power produced by a given disease; the probability of this reduction (or of some disfigurement) being permanent or temporary.

As to the expert's *manner of testifying,* it is hardly necessary here to enter upon the customary platitudes, such as that the expert should always be honest; that he should neither speak too loud nor yet in a whisper; that he should always act the gentleman; never put in technical terms what could be more simply stated; etc., etc. However, one admonition may not be out of place: viz., an expert, and more especially an *expert* expert, as an ophthalmic surgeon is always

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[45]The language of the statute varies, to be sure, in the different states. The matter above quoted is from the Kansas statute.

supposed to be, should ever be exceedingly careful not to express an opinion with too great particularity. This, I think, is a fault to which the specialist is notably prone. He seems, in fact, to feel that he is expected to be very precise and accurate, just because he is a specialist. Nevertheless, he should not testify, for example: "My opinion is that this traumatic cataract was caused by a blow from a heavy cane," for, in fact, no one could tell, merely from the injury, whether a given cataract had been produced by a heavy cane or a light one. To refer to an actual instance: He should not allege that a certain detachment of the retina had been produced by a snowball, squeezed very hard. The same detachment might, in truth, have been produced by almost any solid object impinging upon the eye with violence.[46]

An expert witness, as before stated, may testify either to facts or to opinions; *i. e.*—either in his ordinary or in his expert capacity. When testifying to opinions, his opinions may be based either on facts observed and testified to by himself, or on facts observed and testified to by others. In the latter contingency (and in that alone) the questions which are asked him must ever be fashioned in what is technically known as the hypothetical form. It therefore behooves the medical expert to understand somewhat the nature of *the hypothetical question.*

Now, what is "the hypothetical question?" The hypothetical question is a question which is based upon the assumption that all, or part, of certain facts already in evidence, or yet to be placed in evidence, is true. It *assumes*, or *hypothecates*, the truth of certain fact-testimony, in order that the opinion-witness, *i. e.*, the expert, may have an opportunity to render an opinion thereon. The very reason for the existence of such a form of question, is that it is not the function of the expert, but of the jury, to determine whether or not such fact-testimony is true. The jury may accept the fact-testimony together with the opinion which is based upon it, or the fact-testimony without the opinion, but, under no circumstances, of course, can it reject the fact-testimony and accept the opinion.

Perhaps an illustration will serve to clarify the nature of this important kind of question. Doctor A, an oculist, is called to the

[46]I saw, however, an interesting case of ocular injury (never the subject of legal investigation) in which an expert witness could easily and truthfully have testified with exceedingly great precision. The wound had been inflicted by a butcher with his "steel," or knife-sharpener, on a customer with whom he had had an altercation in his shop. The partly punctured, partly contused, character of the wound in the cornea, together with the presence of raw beef fibres in the anterior chamber and in the conjunctival *cul de sac*, bespoke the nature of the instrument with which the wound had been inflicted, to a high degree of certainty.

witness-stand. Having been sworn and qualified, he is asked, for instance, "What did the defendant then do?" *Ans.*—"He struck the plaintiff with a stick." *Q.*—"On what part of the body did the blow fall?" *Ans.*—"I do not know; I was not close enough to tell exactly." All this, it will be observed, is merely "ordinary," or fact, testimony—such as any witness might conceivably be able to furnish. Suppose, now, another physician, Doctor B, has testified that the plaintiff's uninjured eye is only rudimentary and has never at any time had sight, and, further, that very shortly after the assault he, Dr. B, dressed the left eye (the eye which defendant is said to have injured, and for damages to which the present suit is brought) and that, in the injured eye, he found a sliver of wood 2½ inches long, ½ inch wide, and ⅛ inch thick, impaling the eye "fore and aft," passing from the center of the cornea to the back of the eye, there perforating the wall of the eye and piercing the orbital fat, or cushion on which the eye is supported. In this condition (still other evidence has shown) the plaintiff walked alone six blocks, making three turns, picking his way over crowded crossings, and avoiding by himself numerous vehicles and foot-passengers, that then, still unassisted, he ascended the stairs to Dr. B's office and rang his bell. Now, counsel for defendant desires to show by Dr. A that such acts could not have been performed by anyone with his eyes in the condition above-mentioned. His question will have to be hypothetical, because it is based on facts (and opinions admitted on both sides—which are treated as facts) that had been testified to by others. *Q.*—"Could a man with one eye blind from birth and with the other impaled 'fore and aft' by a sliver of wood 2½ inches long, ½ inch wide, and ⅛ inch thick, passing from the center of the cornea to the back of the eye, there perforating the wall of the eye and piercing the orbital fat, or cushion on which the eye rests—could a person in such a condition have walked, alone and unassisted, six blocks, making three turns, picking his way over crowded crossings, etc., etc.?" *Ans.*—"In my opinion, he could not."

But suppose that Dr. A has been asked to examine the plaintiff, and to report upon the findings. He discovers, let us say, in the plaintiff's left eye a small circular scar of the cornea, 2 mm. in circumference, well off the pupillary area, and, in addition, a sound lens, a sound vitreous, a sound fundus—in short a totally sound eye in every single particular, saving and excepting the corneal opacity only, that being so situated as not to interfere with the sight. The doctor may now be examined *actually*, instead of *hypothetically;* for the reason, as above-stated, that he now is "personally acquainted with the ma-

terial facts in the case."[47] He may be asked, for instance: "What did you find?" *Ans.*—"I found on the left side an eye perfectly sound in every way, excepting a slight scar on the cornea." "Where was this scar situated with reference to the pupil?" "To one side of it." "Does it interfere with the sight?" "No." "Is there anything to show that the eye may not have perfect vision?" "There is not."

It is well enough to note, before we leave the subject of the hypothetical question, that the term "hypothetical" has reference to the sense and not to the mere verbal form. What is really necessary is that the question hypothecate, *i. e.*, assume for the time being, instead of deciding, the truth of more or less of the fact-testimony. A question may, indeed, be cast in hypothetical form (see, for instance, Fairchild v. Bascomb, 35 Vt. 415) and yet, after all, be of such a nature as to require the expert, should he respond, to decide upon the truth of the evidence. On the other hand, a question not at all hypothetical, linguistically considered, may yet avoid the error referred to.[48] The test is: Does the question require the expert to decide upon the truth of any fact-testimony (besides that given by himself, of course) and thus to take that function from the jury?

A subordinate, yet not wholly unimportant, matter is that of the expert's *fees*. We have already seen that, in criminal cases, no fee of any sort need ever be paid or tendered to render valid the service of the subpœna, while, in civil cases, the mileage and *per diem* must always be paid, or tendered, to the prospective witness (whether expert or ordinary) to render the service of the subpœna effective. No payment or tender, no service. Now, in the case of the ordinary witness, that is all the pay there is, even in civil cases. At least it is all that there ever should be. In the case of the ordinary witness, any further compensation is likely to get him into trouble, on the ground of bribery, or even perjury. When, however, the witness is summoned to give, not ordinary fact-testimony, but scientific opinions involving the possession of learning and skill, then a much-mooted question very naturally arises. Ought, or ought not, an opinion witness, an expert, to be obliged by the law to hold his store of knowledge free for the use of all who take it into their heads to litigate? To illustrate: Here is a civil suit against a railway company, brought in the Alexander County, Illinois, circuit court—a case which requires for its proper decision a certain amount of expert medical knowledge and skill. An oculist, we will say, is subpœnaed from Chicago. He is obliged, possibly, to come in person to Cairo, to lose perhaps several days of his practice, and to undergo in addition va-

[47]Rogers on *Expert Testimony*, 1891, p. 75, footnote 2.
[48]Gilwan v. Town of Strafford, 50 Vt. 726.

rious sorts of inconveniences. He has, moreover, to "turn himself wrong side out" for the benefit of people whom he has never seen, who care nothing for him or his interests, and who are striving, the one side to get money, the other side to keep it; and the question is, Shall he do all this for nothing, or, at all events, what is practically nothing—*i. e.*, his mileage and a nominal *per diem*—not quite enough, perhaps, to pay his actual expenses, to ignore the matter of his loss of practice in Chicago? The ablest writers answer the question thus: No, he ought not; the expert's learning and skill are his property, and the law has no more right to compel him to render expert testimony against his will, or at least without adequate compensation, than it has to compel him to render professional services of any other sort. However, the writers and the courts are very much at variance, and, unfortunately for the expert, the courts are not at variance with each other on this question. They hold, with very unusual unanimity, that the expert, medical or lay, may be compelled to testify in his expert capacity without other compensation than that of an ordinary witness. The court of last resort (Supreme Court) in Indiana has indeed held to the contrary, but, even in that state, the decision has been annulled by a statute, while, on the side of the general rule, are ranged the highest courts of Alabama, Illinois, Arkansas, Colorado, Texas, Minnesota, and even of still other states. It has been suggested that the rule, in its actual application, works no injustice, since, in no case whatever, would counsel be willing to take his chances with a medical witness angered by the non-payment, or the prospect of non-payment of extra compensation. This suggestion, however, amounts simply to an insinuation that medical experts will, as a rule, in case they receive no extra compensation, be willing to perjure themselves—an insinuation which physicians, naturally, resent most bitterly. Moreover, in many cases, the party summoning the expert is a pauper, who, of course, cannot pay the "extra compensation" in advance, and who, after receiving a judgment for say ten or twenty thousand dollars, divides the amount with his lawyer, and then, knowing that the law allows no extra compensation to the doctor, says to the medical expert, "For you, nothing." This may happen, too, after the doctor has made most arduous preparation for the case.

However, the situation as a whole is not so bad as the judge-made law would seem to make it. In several states statutes provide for the payment of special fees to experts. Among these states are: Iowa, Louisiana, North Carolina, Rhode Island, and Wyoming.

In any case, where an expert accepts, or is promised, extra compensation, the retaining or receiving of this extra payment should never be made contingent upon the success of the side in whose be-

half the physician is called upon to testify. Everything should be strictly ethical and fair, for the reason, if not for any better one, that the entire matter of the expert's compensation may be brought out fully before the court in his cross-examination.

Legal Considerations Regarding Ophthalmic Expert Testimony in England.

In England the law relating to expert witnesses is much the same as in America. In fact, in neither of these lands is there anything at all resembling an official corps of medical experts, such as, later, we shall find exists in Germany and France.[49] Furthermore, as we saw some distance *supra*, the common law (decisions of courts of last resort) in America has a certain degree of persuasive authority in the courts of England, just as the reverse holds true.[50] It is, then (partly, no doubt, in consequence of this persuasive authority) a fact that the English law relating to expert testimony is almost identical with the law on the same subject prevailing in America. The method of securing attendance in court, the rulings with regard to competency, the procedure relating to examinations and cross-examinations, etc., etc.—these and various other affairs relating to expert—as well as ordinary—witnesses, are managed in England almost the same as in America. Especially worthy of notice is the retention in the Mother Country of the old-time rule already adverted to in this chapter of excluding the testimony of physicians from the list of matters regarded by the courts as "privileged." Thus *The Encyclopedia of the Laws of England*:[51] "The statute law of many foreign countries enforces this obligation [of medical secrecy] by penalties, and regards it as sacred even in the witness-box. English law, however, takes a different view, and, if the judge sees fit, compels a medical witness to reveal in open court the most confidential communications, and to disregard the most solemn promises." In England, therefore, the law on this point is exactly the same as it is in the different states of the United States (for example, Illinois) where the matter has not been changed by statute.

Legal Considerations Regarding Ophthalmic Expert Testimony in France.

The medical expert system of France, though not entirely transferrable to a Common Law country like ours, is nevertheless so excellent and in so many particulars, and, moreover, spite of the recent date of its adoption, has worked so admirably, that we take great pleasure in presenting it here with just a suggestion of detail.[52]

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[49]But not Italy.
[50]American cases are frequently cited in English text-books and vice-versa.
[51]1900-1909, Vol. 9, p. 126.
[52]I am informed by an eminent French authority that perhaps the only objection which could properly be raised to the French expert system is

We shall deal with the subject under the heads of: (1) Appointment of medical experts. (2) Procedure of medical investigations in civil matters. (3) Procedure of medical investigations in criminal matters. (4) Medical expert reports.

Appointment of Medical Experts.—At the commencement of each judicial year, and in the three months following the opening of the court, the Court of Appeal, sitting in council, together with the aid and consent of the procureur general, appoints from a list prepared (as stated heretofore) by the civil tribunals of first instance a number of physicians on whom the appeals court confers the title of "expert before the courts." In the Court of Appeals of Paris, the appointments in question are made by the first three chambers of that tribunal.

The conditions of eligibility to appointment by any Court of Appeals are: 1.—That the physician be of French nationality.[53] 2.—That he have his legal domicile either in the arrondissement of the tribunal, or, at all events, within the territorial jurisdiction of the Court of Appeal by which he is appointed. 3.—That he shall (a) have had at least five years of the actual practice of his profession, or (b) be furnished with a diploma from the University of Paris bearing the mention, "Legal Medicine and Psychiatry," or one of the analogous diplomas conferred by the other French universities.

Expert investigations and examinations may, in general, be conducted only by physicians who bear this title of "Expert before the Courts," and, as a natural consequence, such experts appear in every class of cases and in every court, even the Court of Cassation. According to the Code of Criminal Procedure,[54] however, other physicians may be appointed in cases of "flagrant crime, inquiries ordered by a Court of Appeal, or measures taken by the president of a Court of Assizes by virtue of his discretionary power." Other cases in which non-intitulated experts may be appointed are: When the experts properly intitulated by the Court of Appeals are for good reason disqualified to act in a particular case (as by consanguinity, affinity, personal interest in the suit, etc.) when there is great urgency, and also in other cases by reason of special circumstances. In every

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that "experts are not always appointed with a great deal of care." Thus, for example, general practitioners are not infrequently assigned to duties that properly belong to the field of specialism, and *vice versa*. Again: "It has happened that the court in certain instances has appointed a specialist in one matter as expert in regard to another specialty."

[53]The law on this point is very explicit and positive: "Les fonctions de médécins experts près les tribunaux ne peuvent être remplie que par des docteurs en médecine français."—L'article 14, Sec. 1er de la loi du 30 Novembre 1892.

The German law is by no means so particular.

[54]*Code d'instruction criminelle*, articles 43, 44, 235, et 268.

case, however, of such anomalous appointment, the order of appointment must be supported by a written statement of the reasons for which the anomalous appointment is made. Further, even in the case of anomalous appointments, the appointee must be a French physician.

The experts are appointed either by the court or by the parties, sometimes by the parties and the court acting conjointly.

The foregoing rules relating to the qualifications and the appointment of medical experts, apply indifferently in civil and in criminal matters. The procedure, however, according to which expert investigations are conducted, differ somewhat in the two classes of cases.

Procedure of Medical Investigations in Civil Matters.[55]—1.—The expert, or experts, whether appointed by the courts or chosen by the parties, are not obliged to accept either the appointment or the choice; but, the mission once accepted, its duties are obligatory and must be completely performed. If they are not fulfilled completely, the expert is obliged to defray all frustratory expenses, and also to pay (sometimes very heavy) damages.

2.—Expert witnesses, like common witnesses, may be challenged on grounds of relationship, affinity, etc.

3.—Experts must take a certain oath, not necessary here to be specified.

4.—Expert investigations must be conducted (when it is proper so to do) in the presence of the interested parties or those who lawfully represent them. For reasons of expediency, however, the presence of the parties may be dispensed with. But even then, the parties should have a chance to be represented by a physician, or physicians, of their choice.

5.—If several experts be chosen or appointed, they should construct but one single report. In case there should arise a diversity of opinions among the several experts, all the different opinions may be stated in detail, but no particular opinion may be attributed to any particular expert. All the different opinions must proceed from the board of experts as a whole.

Procedure of Medical Investigation in Criminal Matters.—1.—Medical experts, in criminal matters, are not invariably at liberty to reject an appointment by the court. They may do so only in certain cases.

2.—An expert may be successfully challenged, in criminal mat-

[55]These rules, somewhat abridged and otherwise modified, are taken from Simon-Auteroche, "*Manuel Pratique de Droit Médical*," *Paris*, 1908, pp. 108-112.

ters, much more readily than in civil affairs. "There must not be the least suspicion of prejudice or partiality, even involuntary."

3.—It is not at all necessary that the operations of the experts be conducted in the presence of the parties or of those who legally represent them.

4.—The report of the experts may, if expedient, be verbal. (It may not, under any circumstances, be verbal in a civil suit.)

5.—Medical experts must invariably be placed under oath both before commencing their investigations and, once more, before they testify in court.

Reports.—Expert reports, according to Simon-Auteroche,[56] are composed of four essential parts:

1.—Preamble (reciting the names of the experts, the order of the court by virtue of which the investigation was made, etc.).

2.—Statement of the facts.

3.—Discussion.

4.—Conclusions.[57]

Legal Considerations Regarding Ophthalmic Expert Testimony in Germany.

In Germany, too, as well as in France, there exists a corps of official expert witnesses. In Germany, however, the system is, in a manner of speaking, a "blend" of the French and the Common Law systems; that is to say, although there exists in Germany a corps of official experts, yet these do not so uniformly appear before the courts—*i. e.,* to the almost total exclusion of non-official experts—as is the case in France.

The power to regulate medical affairs resides, in Germany, in the first instance, with the imperial authority, but these matters have, for the most part, been delegated to the separate Bundesstaaten, so that, in the different Confederated States, there obtain somewhat different systems of medical experts. However, to take the organization of the Prussian experts for an example: The head of the corps is the "Minister der geistlichen Unterrichts- und Medizinal-Angelegenheiten." Under this official functionates an "Abteilung für die Medizinalangelegenheiten," a branch of which is the "Wissenschaftliche Deputation für das Medizinalwesen," the highest consulting class. Each province has its "Provincial-Medizinal-Kollegium," each county its "Kreisärzte."

The members of this official medical corps take on the duties of

[56]*Loc. cit.*, p. 112.

[57]We do not enter here into the question of privilege or non-privilege with respect to medical testimony in France. The subject is extensive, and may be found fully treated (if not absolutely up to date) in Brouardel's "*Le secret médical, Paris*, 1893.

expert witnesses only when called upon by the police or the State's Attorney *(Staatsanwalt)*.

In addition to the system above mentioned, there are in some of the larger cities of Prussia the so-called *Gerichtsärzte*, or (law) Court Physicians.

An appeal lies from the report of a Kreisarzt or a Gerichtsarzt to the *Provinzial-Medizinalkollegium*, and, still further, to the *"Wissenschaftliche Deputation,"* this last-mentioned body being the highest consulting class, or, as it were, supreme court, for medical expert matters in Prussia.

Numerous forms are furnished and directions given for the construction of medical expert reports. Non-official experts are bound to follow the forms in certain matters only, while the official experts are obliged to make use of them in practically every sort and kind of case.[58]

The experts for any individual case are appointed by the Court. The appointees, however, can, for cause, be challenged by the accused, the complaining witness, the prosecuting attorney, and, in civil cases, by the plaintiff or the defendant. In civil suits the parties are not infrequently permitted to select the experts for themselves.

In connection with the subject of expert testimony, it is worth our while to note that, in Germany, professional secrecy is very rigidly enforced. Thus the Penal Code *(Strafgesetzbuch)*, sec. 300: "* * * Physicians, Surgeons, Midwives, Pharmacists, and any assistants of any such persons, shall, in case without authority they reveal private matters, which have been entrusted to them in consequence of their callings, be punished by a fine not to exceed 1,500 marks or by a jail imprisonment not to exceed three months."

However, in a court of law, professional secrets are, of course, legally divulgeable up to a certain extent. To exactly what extent the law is very specific in many respects, though not all, laying down various regulations regarding non-official and official experts and also others as to official experts after these have ceased to occupy their official positions.[59]

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[58]Rapmund-Dietrich recommends to non-official experts the following of official forms in every case. *"Arztliche Rechts- u. Gesetzkunde,"* Leipzig, 1899, p. 462.

By the way, those who desire to behold a combination of Teutonic scientific and legislative thoroughness in one single documentary masterpiece, are referred to the Prussian *"Regulativ vom* 14 *Februar*, 1875" (concerning the manner of performing obductions and constructing reports upon the findings) contained in the work of Rapmund-Dietrich just mentioned, p. 475 ff.

[59]Thus, for instance, the *Code of Civil Procedure* (*Civil-prozessordnung*) Sec. 376: *"Oeffentliche Beamte, auch wenn sie nicht mehr im Dienste sind, dürfen über Umstände, auf welche sich ihre Pflicht zur Amtsverschwiegenheit bezieht, als Zeugen nur mit Genehmigung ihrer vorgesetzten Dienstbehörde*

In general, a witness is neither punishable criminally nor responsible in a civil suit for damages on account of any testimony which he may have given (veraciously, of course) on the request or demand of a court of proper jurisdiction.

Legal Considerations Regarding Ophthalmic Expert Testimony in Italy.

In Italy there is no corps of "experts before the courts." Any physician practising in Italy may be cited to appear and serve as an expert.[60]

It is, however, absolutely necessary that a man, in order to be competent as an expert, should be a licensed physician. He is not, nevertheless, *required* to be in active practice at the time of acting in his expert capacity.

In damage suits, based on injury to special organs, the expert witness need not be a specialist in diseases of the organs concerned; nor is there any law forbidding a specialist who practises only a specialty, to render expert testimony outside his particular field.

A related matter is that an expert witness of one school of practice is allowed to testify in a suit for malpractice against a physician of another school.[61]

In criminal cases the number of experts is, as a rule, two; in civil cases, however, either three or one. In criminal cases the experts are appointed by the court (though the appointees may for just cause be challenged); in civil cases the parties agree upon their experts, or, in case of their inability to agree, the experts are selected by the courts.

All experts selected by the courts are paid from the public treasury. Those selected by the parties are compensated by the parties, except where one or more of the parties are indigent—then the public treasury is once more called into requisition.

We may add, finally, that, in criminal cases, the court has power not only to compel the experts to attend and deliver testimony, but also to prepare themselves therefor by laborious investigations.[62]

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oder der ihnen zuletzt forgesetzt gewesenen Dienstbehörde vernommen werden." The *Code of Criminal Procedure* (*Strafprozessordnung*) Sec. 53, holds precisely the same language.

[60]There is, to be sure, a corps of sanitary physicians grouped in a kind of hierarchy, as in Germany; but this is an altogether different affair from a corps "of experts before the courts." This sanitary corps will be treated under the heading of *Ophthalmo-Sanitary Legislation in Italy.*

[61]As before mentioned, only in the United States is it forbidden that an expert of one school shall testify in a suit for malpractice against a physician of any other school. Surely in this particular the law of the United States is very much in advance of that of any other nation.

[62]In the United States a physician can be required to attend a trial and to give impromptu answers both in civil and in criminal cases. He cannot, however, in either class of cases, be required, against his will, to make any sort or kind of preparation for the giving of his testimony.

B.—SURGICAL CONSIDERATIONS REGARDING OPHTHALMIC EXPERT TESTIMONY.

The surgical side of the subject of expert testimony relates (so far as concerns the purposes of this chapter) to the following matters: The commonest injuries with which the ophthalmo-surgical expert witness has to deal; simulation and the tests therefor; the false attribution of injuries and diseases and the tests for that subtle form of falsification; exaggeration and the tests for that; dissimulation and cautions; visual economics; questions of a general nature relating to the power of vision and the condition of the eye after death and during sleep; the ocular signs of poisoning, burning, etc.; and, finally, the ocular indications of identity.

The Commonest Injuries with Which the Ophthalmic Expert Has to Deal.

Injuries of the sort in question are: Wounds and burns of the ocular adnexa (the eyebrows, the eyelids, and the extra-bulbar contents of the orbit); wounds and burns of the ocular conjunctiva, the cornea, and the sclera; and, lastly, wounds of the deeper portions of the eye.

Wounds of the eyebrow are generally very simple and altogether harmless, directly and indirectly. There is swelling perhaps, and ecchymosis, and a little throbbing pain. Resolution, as a rule, is prompt. Sometimes, however, instead of resolution, there follow periostitis, suppuration, and necrosis. Also, the outer wall of the frontal sinus may be crushed in, with resulting chronic empyema of that cavity. The supra-orbital nerve may be injured in such manner that the traumatism is followed, after a time, by persistent neuralgia. This is generally when the nerve is incarcerated in an adherent cicatrix.

It is now and then important to differentiate between contused wounds of the eyebrow and incised wounds of the same part. Such a distinction would, at first thought, seem sufficiently easy in almost every instance; yet, as a matter of practice, this is not at all the case, for contused wounds of soft parts which are underlaid by prominent bony ridges have a way of looking almost precisely as if they had been occasioned by an instrument possessed of a cutting edge. Thus, I have seen a case where a man had had his eyebrow split by a blow of a fist almost as cleanly as if the injury had been produced by a knife; yet I myself had seen the blow delivered, and was certain that nothing but the naked fist had been employed.[63]

The distinction between the apparently incised, but really con-

[63]I have also seen an eyebrow split by a pair of brass knucks so cleanly that, without the carefulest examination, one would almost be willing to swear that the wound had been made by the sharpest of knives.

tused, wound of an eyebrow, and an incised wound of the same part, is made by three indications: First, the wound which is really contused is more likely to possess an areola of ecchymosis. Second, under a lens, the walls of a contused wound are seen to be not actually smooth, but more or less ragged. Third, while an incised wound shows all the tissues divided just as deeply down as the wound reaches, a contused wound simulating an incised wound, shows some of the more resisting tissues, or fibres, undivided, while others, deeper down in the wound, are severed. Fourth, the really contused, though apparently incised, wound is generally more extensive (longer) at the bottom than at the surface, while the really incised wound is apt to possess a so-called "tail" both at the beginning and the end—in other words, to be of greater extent in the skin than in the deeper tissues. This distinction is due to the fact that, in the really incised wound, the inflicting instrument cuts from without inward, whereas, in the case of a wound of the contused variety, the incising instrument—the bone—cuts from within outward.

This distinction is often important, as, on the expert's ability to make it, not infrequently, at the preliminary trial, hinges the question whether a defendant is to be held for assault with intent to kill, or only charged with simple assault and battery. Later, the distinction and the expert's ability to make it, may mean to the accused the differences between the penitentiary and freedom.

The distinction above mentioned is similar to that (which is also very important) obtaining between an incised wound about the body almost anywhere and a wound produced artificially (artefact) by the lifting and carrying of a body which has been severely burned, or cooked. A burned body is found, perhaps in the ashes of what was once a house. Certain solutions of continuity appear in divers places about this body, suggesting the inquiry whether a murder has not been committed and then the house set fire to, in order, by incinerating the body, to cover the traces of the crime. On the other hand, the question arises whether the fissures, or apparent incisions, may not have been produced in the easily parted tissues by the lifting and carrying of the body from the site of the burning. Now, when a deep fissure is produced in burned tissues by the lifting and carrying of the body, there will often be fibers, high up in the fissure, which have not parted. Thus is easily and certainly established the fact that no incised wound had been inflicted before the body was burned; for, in the case of a wound by a cutting instrument, all the tissues would be divided down to the very bottom of the incision.

Sometimes an injury to the eyebrow is complicated by suppuration of the orbital connective tissue (orbital abscess) and even though this

abscess be properly evacuated, and the prospect of recovery is, for a time, apparently good, total loss of sight may nevertheless follow later, by reason of the cicatricial tissue formed in the suppurating cavity slowly contracting round the retro-bulbar portion of the optic nerve.

Fracture, direct or indirect, of the optic foramen is a not very infrequent accompaniment of severe contusions in the superciliary region; and, in such cases, a retro-bulbar neuritis (often of very slow onset) may develop, with the production of blindness more or less complete and absolutely hopeless. Secondary retro-bulbar neuritis may also occur in consequence of various effusions or of the pressure from callosities which, in their turn, have been produced by periostitis.

Fracture of the base of the skull, with meningitis and death can also occur as a complication of contusions of the eyebrow.

From all the above-mentioned considerations it appears that the ophthalmo-surgical expert should be extremely cautious when setting forth the ultimate prognosis of injuries to the eyebrow.

Burns of the eyebrow are generally not important. If other ocular structures are involved, the fact is sufficiently patent. It is often the case, however, that cicatricial contraction follows in the wake of superciliary burns, with consequent great disfigurement.

Wounds of the eyelids, without the involvement of deeper structures, are generally unimportant, and, owing to the carefully protected situation of the eyes, are not common. The danger is that deeper structures may be involved. Infection, also, may turn an apparently trivial trauma of an eyelid into a matter of life and death, in consequence of the resulting erysipelas, lock-jaw, etc. Further, a wound which, on any other account, would be sufficiently trivial, may prove serious indeed if the lachrymal canaliculus be involved, because, by obstruction of this passage through the formation of cicatricial tissue, epiphora (or running of the tears down onto the cheek, instead of through the lachrymal passages into the nose) is produced, and much consequent interference with vision, on account of the continual presence of tears on the front of the eyeball. Sometimes, too, a traumatism of the eyelid gives rise, through closure of the ducts of some of the Meibomian glands, to Meibomian cysts; but these are comparatively harmless and are very easily remedied.

Burns of the eyelids are much more serious than uninfected eyelid wounds, because, after burns, cicatricial contraction may so distort the lids that they no longer fulfill the important offices for which they were provided. Thus, after a mine explosion, in which the outer surfaces of the lids were deeply burned by the flaming gas, I have over and over beheld almost incredible distortion of the lids, with ulcerating corneæ (due to the lagophthalmos) and blindness. Often plastic op-

erations can advantageously be performed in these cases; oftener, however, operation is refused, and the mining company is likely to be held responsible for the blindness that follows in consequence of the refusal. The various entropium and ectropium operations often find a place, of course, after eyelid burns, as well as electrolysis for distorted eyelashes (traumatic trichiasis).

Injuries to the extrabulbar contents of the orbit, without a complicating injury of the eyeball itself, are quite rare, and yet they do occur. Thus, I have taken from the orbital fat a peach-tree twig two inches long; in another case, a sliver of glass; and, in still another instance, a short ball from a 22 caliber cartridge, without in any of these cases the eyeball being injured. Various disturbances of the ocular motility can be occasioned by injuries to the extrinsic muscles, these amounting at times to complete solution in the continuity of one or more of these contractile structures. Orbital abscess is not infrequent as a result of extrabulbar orbital injuries, especially when these are complicated by the presence of foreign bodies. The great danger, of course, in such cases, is to the optic nerve, which, by reason of cicatricial contraction taking place around it, is prone to undergo atrophy. Disturbances in the motility of the eye may also be occasioned by cicatricial contraction in the neighborhood of the various muscles, or, at an earlier stage, by sloughing of the muscular tissues themselves. Suppurative meningitis is also a possible consequence, or complication, of orbital abscess.

Wounds, with or without remaining foreign bodies, and burns of the conjunctiva, the sclera and the cornea are among the commonest of injuries, and are not infrequently the ground of hard-fought litigation. An incandescent particle of iron will often inflict a wound, produce a burn and leave at the place of injury a foreign substance, all at the same *coup*. Many foreign bodies are expelled by the various provisions of nature looking to this end, while others are removed (sometimes unfortunately so, by reason of the infection introduced) through the instrumentality of fellow workmen. A fellow workman, in fact, sometimes employs his tongue as the removing instrument! Sometimes an eye is struck by a foreign body, which then rebounds away from the eye, leaving, however, a contusion of the cornea (with or without infection) and then an ulcer follows. The workman, in such cases, can hardly ever be convinced that "there is nothing in his eye." He has so often had a foreign body picked from his cornea, that he has come to believe that a foreign body of some kind, must, as a matter of course, be present whenever his eye is injured. Should the eye go out, or suffer a material diminution of its vision, the patient's animosity, as well as his attempts at legal redress, are more likely to be directed to-

ward the surgeon than toward the employing company.[64] Burns of the conjunctiva, sclera, and cornea are usually complicated by similar conditions of the lid. They are oftenest produced by steam or burning gas, but now and then take their origin from the action of chemical agents (the various caustic acids and alkalies) as well as from heated pitch, water, wax, oil, and molten or solid metals, including such explosives as fulminate of silver or mercury, used in percussion caps and boys' torpedoes. They are nearly always of serious prognosis, being in many instances followed promptly by perforation of the globe. Burns by acids and alkalies (oftenest quick-lime) are likely to be not only deep but also complicated by extensive adhesions between the lids and the ball (ankyloblepharon, symblepharon, etc.). In many of the cases the surgeon can afford but little assistance. It should be recalled, to be sure, that partial symblepharon is easily cured by a simple operation. I have seen some cases of ocular burns that promised to be of the greatest severity, but which, nevertheless, gave very good results. Such was a case in which a man had filled a large hole in a base-stone with melted solder, and then, into this molten metal, had tried to set the lower end of a cold iron pillar. He was stooping close down over the stone, guiding the pillar with his hands into the solder-filled socket, when, just as the iron touched the hot solder, the metal splashed up and into his right eye. When he came to me, he seemed to be wearing a metal mask over the right eyeball. This curved plate of metal I had no difficulty in releasing from the conjunctival *cul-de-sac,* and then, behold an eyeball perfectly unharmed, except for a trifling hyperemia! The workman informed me that he had been the subject of this identical accident before, without receiving the slightest harm, and a few months later, he came to my office again with a similar mask of solder before the same identical eye. Once more I removed the metal plate, and once again, I found an uninjured eye.[65] Red pepper, too (so often thrown into the eyes on purpose) though it causes most atrocious pain, is seldom followed by any serious permanent injury.

Such exceptional matters aside, however, the prognosis in burns of the surface of the eye is always very grave, and a final opinion should never be passed till the lapse of several months. Especially after the action of quick-lime or fresh mortar, and the fulminates of silver and mercury, should the prognosis be extremely guarded.

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[64] Much depends on the state of the doctor's finances. Experience shows that the number of suits for malpractice which any physician is likely to be subjected to bears a direct proportion to his financial standing. "Where the honey is, there will the flies be also," is true here as elsewhere.

[65] Noyes. *Diseases of the Eye*, 1894, p. 288: "Burns by melted metal are often less severe than those due to lime, because when the metal cools it is taken out as a cup, and there is no continuously destructive chemical action."

The *iris* is not infrequently involved in wounds of the eye, whether the ocular coats have or have not been opened. In severe contusions (produced, for instance, by a blow of the fist, or a hard snow-ball) the iris is now and then detached at its circumference more or less completely. An incomplete detachment is known as *iridodialysis;* a complete one, as *irideremia,* or *traumatic aniridia.* Detachment is much more likely to occur in the case of irides already adherent to the lens, or the subject of inflammation at the time when the contusion was inflicted. Hence, the prospective expert witness should always enquire carefully as to the existence of these predisposing causes. If the crystalline lens has been dislocated backward (sometimes without such dislocation) the iris may suffer inversion (retroversion, or retroflection)—a condition which often closely simulates iridodialysis and irideremia. The distinction is easily made by the fact that, under the ophthalmoscope, the ciliary process will, in retroversion, be found to lie concealed, but not in iridodialysis or irideremia. In the latter two conditions, further, there is much more likelihood of considerable hyphemia being present on account of the necessarily ruptured iris tissues.

Rupture of the sphincter iridis without iridodialysis or irideremia, is rare indeed, but has occurred a number of times. It is apt to be accompanied by hyphemia, and is always attended by traumatic mydriasis.

Traumatic mydriasis without rupture of the sphincter iridis, is not uncommon, and is due to paralysis of the sphincter iridis.

All of these affections (except traumatic mydriasis without rupture, which now and then disappears spontaneously) are absolutely incurable.

The loss of earning power consequent upon any of these iris injuries can only be determined in any particular case by actual investigation. Sometimes, even after complete traumatic aniridia, the vision is but very little disturbed; again there may be monocular diplopia, dazzling, etc., those who work much in the dark—*e. g.,* coal miners—are least inconvenienced. If severe iritis or irido-cyclitis follows, the sight may be entirely lost.

Liable to be mistaken for the results of trauma, are the following natural anomalies of the iris:

Heterophthalmos, or difference in the coloring of the irides of the two eyes. I have known such a condition to give rise to a mistaken diagnosis of traumatic iritis.

Corectopia, or *ectopia pupillæ,* or malposition of the pupil.

Polycoria, or more than one pupil in the same eye.

Persistent pupillary membrane, or fetal remains which present themselves ordinarily as fine grayish or brownish threads stretching

from iris to lens, or spanning the pupillary gap completely. Such threads are now and then mistaken for posterior synechiæ, but can easily be distinguished from such pathological products by the fact that, unlike posterior synechiæ, they do not spring from the pupillary margin but from a point a little farther out than that, from some point, in fact, on the *circulus iridis minor* on the anterior surface of the iris. Posterior synechiæ spring either from the margin of the iris or from its posterior surface. Another point of distinction is that under atropin, these threads, or bands, prove to be very elastic; the pupil, in spite of such threads, dilating quite smoothly and round.

Congenital coloboma of the iris is very often mistaken either for an artificial coloboma, or else for a retroflection, or retroversion, of the iris, due, of course, to trauma. In a congenital coloboma, however, the sphincter iridis continues into and round the gap unbrokenly, whereas no sphincter appears in a coloboma due to traumatism or in the gap produced by a folding backward of the iris. Further marks of distinction are: A congenital coloboma is almost always situated below (though exceptions to this rule exist); and, moreover, a congenital coloboma is often, perhaps usually, associated with coloboma in the choroid, the ciliary body and the lens.

A special importance attaches to the differential diagnosis between a congenital coloboma of the iris and an artificial coloboma, or a retroflection, from the fact that eyes afflicted with congenital coloboma are very often partly, and sometimes completely, blind. Therefore, a claimant might readily attempt to attribute to traumatism what was, with him, a natural condition.

Foreign bodies in the anterior chamber and in the iris, usually enter by way of a perforation in the cornea; in very rare instances, they enter sidewise *(via* the lens) or from the rear. Whether in the iris or the anterior chamber, their presence may be tolerated indefinitely, but, as a rule, they sooner or later set up a low grade inflammation which gradually spreads to the ciliary body and the other intraocular structures with resulting intraocular abscess, or, more frequently, ocular atrophy. The worst feature of such cases, however, is the tendency toward the setting up of sympathetic ophthalmia. Without extraction of the foreign body, prognosis is always grave.

The choroid and the ciliary body when injured, whether or not a foreign substance is left within these structures, present perhaps the most serious conditions with which the ophthalmic surgeon is called upon to deal. Even a slight contusion upon the eye may cause a hemorrhage from the structures (especially in anemic persons, or those who are suffering from arterio-sclerosis or high degrees of myopia) and the extravasated blood may collect between the choroid and the

sclera, or else, which is much more serious, between the choroid and the retina. Sometimes the hemorrhages are slight and promptly absorb. In such cases the vision does not suffer. Oftener, however, the choroid is detached, or the retina, and then the eye is almost invariably lost—in the former event from irido-choroiditis, and in the latter, from the tendency which any detachment, however slight, of the retina, displays, to become complete.

Ruptures of the choroid are generally situated between the optic disk and the macula lutea. In the simpler cases, the vision, which immediately after the injury is nearly always bad, rapidly improves, but scotomata are nearly always left permanently, and a perfect result is the very rare exception. In the graver cases, the sight is nearly always permanently lost, owing to detachment of the retina, hemorrhage into the vitreous and other complications.

Perforating wounds of the ciliary body, if they lie in a direction parallel to that of the ciliary folds, are often of good prognosis; if, however, they lie diagonally across the folds, or transversely, the eye is generally lost by atrophy, and there is in such cases a marked tendency toward sympathetic involvement as well.

In case a foreign substance is left in the ciliary body, the prognosis is, of course, even graver.

The *retina* is hardly ever injured by itself, for penetrating wounds of this membrane of course involve some of the other structures necessarily; while even a rupture of the retina, produced by a contusion, is likely to be accompanied by solutions of continuity in the choroid. Retinal ruptures produced by contusions nearly always occur by *contre-coup.*

The slightest of all the injuries of the structure in question is known as *commotio,* or *concussio, retinæ.* The retinal changes which are designated by this name have been mistaken for retinal detachment, and, as they nearly always undergo perfect resolution and that very quickly, they are hence important in a legal viewpoint. The distinction between concussion and detachment is made by the following signs: In concussion the retinal vessels are wholly undisturbed, showing no parallactic movement or increased hypermetropia, the opposite state of affairs presenting itself in retinal detachment. Further, in concussion, the retinal plications, or folds, occurring in detachment, are absent. Finally, a concussion (which is always recent) is never quite so white or so opaque as a recent retinal detachment.

Other forms of retinitis than the relatively unimportant *concussio,* are far more serious. Such, for instance, are the *retinal changes at the macula lutea,* neither commotio nor detachment, following contusions of the globe and nearly always serious and permanent. In fact the

visual disturbance, being macular, is well-nigh always incapacitating, so far as the earning power of the injured eye is concerned. An important matter to remember is that the changes in question are of very slow development in the vast majority of cases, weeks being required in some instances before the visual difficulty appears. In such cases, of course, the question often arises, especially in court, why was it that, if the eye was so severely injured as is claimed, the plaintiff did not observe the fact until several weeks after the accident—until, indeed, other persons perhaps had found it possible to recover for *their* injuries received at the same place and at the same time.

Hemorrhage confined to the retina is generally of little import permanently. There is often for a time, especially if the bleeding be central, erythropsia and metamorphopsia. Whether central or not, a hemorrhage is almost always accompanied by a scotoma. These appearances, however, provided the extravasated blood does not break its way into other structures, are very evanescent.

Detachment of the retina, however, may occur in consequence of large effusions of blood, though oftener by far it is produced primarily by contusions or perforations of the globe. Occasionally the retinal separation is consequent (at a late date) upon the contraction of cicatricial tissue, either in the vitreous or in the retina itself. Extensive loss of vitreous is not infrequently responsible for its production. The amount and kind of visual disturbance depend, of course, upon the extent and situation of the retinal detachment. Contraction of the visual field and scotomata correspond pretty closely to the portions of the retina that are detached, and metamorphopsia (distorted vision) together with erythropsia (red vision) in the case of hemorrhages, is apt to precede the formation of the blind areas, and to diminish *pari passu* with the increasing blindness.

Prognosis is always bad, although traumatic detachment of the retina is oftener followed by complete recovery than are the other varieties.

The *crystalline lens,* as a result of traumatism, may undergo displacement (luxation or subluxation) or be rendered opaque (traumatic cataract) or become the seat of a foreign substance. Luxation, partial or complete, may be the result of a penetrating or rupturing wound of the eyeball, or merely of a contusion or compression of the eye. It is said to have happened as a result of concussion sustained by the skull, and even by the neck and the feet (as in falls from a height). Even in partial dislocation there is loss of accommodation and sometimes monocular diplopia. In backward dislocations, the iris becomes tremulous (iridodonesis) by reason of loss of the normal support which is afforded to the iris by the lens. In case the lens is so displaced as to

lie with its margin across the pupillary area, one part of the eye may be extremely hypermetropic and the other myopic. Complete dislocation into the vitreous means, refractionally at least, aphakia (as after a cataract extraction) hence an extreme degree of hypermetropia—unless, indeed, the eye was very myopic to begin with. In some cases of partial dislocation, the diagnosis can only be made after atropinization and then by means of the ophthalmoscope. Forward dislocations are sufficiently obvious even to beginners in ophthalmology.

It should be remembered that displacement of the lens is now and then congenital. Thus, P. H. Adams, of Oxford, England, reports the case of a family with congenital displacement of lenses, in which the mother and seven out of nine children suffered from this condition.[66]

Partial dislocations can sometimes be remedied, though never fully, by means of spectacles. Even then, however, the great difference in the refraction of the two eyes (anisometropia) renders impossible the simultaneous employment of both organs, and hence the victim of the accident is rendered monocular to all intents and purposes, except that he possesses in the vision of the injured eye a moderate reserve of sight to draw upon in case the fellow organ should go blind from any cause at some time in the future.

Complete dislocation into the vitreous does not call for extraction, or other form of operation, unless productive of irritation. Glasses prove of benefit in this condition under the same conditions, as a rule, as in partial dislocations. Complete dislocation forward—*i. e.,* into the aqueous, is so often followed by chronic glaucoma, lenticular opacity (cataract) and adhesions to the iris and cornea that, in the great majority of cases, extraction of the lens is necessary. In any case of dislocation of the lens, forward or backward, partial or complete, the lesion is apt to be followed by lenticular turbidity (cataract). This may render operation necessary at a later date.

Traumatic cataract without lenticular dislocation is often a consequence of injuries to the eye, accompanied or unaccompanied by perforation or rupture of the ocular tunics. If entirely uncomplicated, these cases can usually be conducted to a successful termination (the younger the subject the greater the probability of success) so far as respects the injured eye alone. However, the eye can never be employed to advantage simultaneously with the fellow organ, excepting only in the extremely rare instances where the fellow eye was already aphakic or extremely hypermetropic.

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[66]Report of June meeting of the Ophthalmological Society of the United Kingdom, *Medical Press*, June 25, 1909, abstracted in *Ophthalmology* for Nov., 1909, Vol. VI, No. 1, p. 105.

A foreign body in the crystalline lens means, as a rule, progressive opacity of that structure. A wide pupil and oblique illumination are often prerequisite to the discovery of the intruding substance. In my experience, small foreign bodies in the lens, if not amenable to a magnet, are better left alone, for, now and then, the expected cataract never develops, and the patient retains an extremely useful organ, whereas, if necessary, operative interference can be instituted at a later date. Much depends, of course, upon the extent of the injury suffered by the lens, and on the character (as regards probable asepsis, etc.) of the offending substance.

Wounds of the vitreous humor are not as a rule important, except so far as they imply an injury to other and more iritable structures—the retina, the choroid, etc. In other words, simple compression or contusion of the eye, seldom results (owing to the elasticity of the vitreous) in serious injury to the vitreous humor, excepting when a hemorrhage from the coats of the eye, breaks through the limiting membrane (hyaline membrane) or when an exudate is poured out into the vitreous from the ocular coats. In cases of hemorrhage into the vitreous, the outlook, though not hopeless, is bad. I have seen in young patients, after moderate hemorrhage, complete recovery in every portion of the field; but, in the vast majority of cases, positive scotomata, movable or immovable, remain, impairing the sight and earning power according to their extent and to the parts of the visual field to which they correspond. In cases of exudate, connective tissue bands are formed in the vitreous, and these, contracting, cause detachment of the retina and choroid, together with atrophy of the eyeball.

When the coats of the eye are perforated, hemorrhage and exudate into the vitreous are far more likely to occur, together with retinal and choroidal detachment, and, in addition, there may occur an intraocular abscess. Prognosis depends on the site of the injury, the presence or absence of infection, the quantity of exudate or blood poured out, the amount of vitreous which has escaped from the eye, and, finally, on the presence or absence of a foreign body.

Foreign bodies in the vitreous may arrive in that humor after a journey through almost any part of the enveloping membranes. Perhaps most frequently they pass through cornea and lens; often, however, through sclera, choroid, and retina. They consist, for the most part, of bits of metal and stone, but particles of coal, wood, and other substances have often been found in the vitreous.

Diagnosis is often difficult. There may manifest themselves at once scotomata and peripheral contractions. Sometimes the path which has been taken by the offending substances can be discerned, either by the naked eye (lateral illumination should be employed) or by means

of the ophthalmoscope; this, again, may be impossible, owing to a great variety of circumstances. Sometimes the ophthalmoscope reveals the foreign body with much distinctness, often, however, the quantity and situation of the hemorrhage forestalls even the haziest kind of view. Air bubbles in the vitreous are highly suggestive, but not absolutely pathognomonic, for they may occur even when the coats of the eye have not been perforated. Magnetic needles have been devised for the purpose of detecting the presence of metals which, like steel and iron, exert an influence upon magnetic substances. The giant magnet is, with regard to such particles, both an excellent means of diagnosis and a splendid instrument for removal. In very many cases, too, the X-ray gives valuable information; in fact this agent, in a very large number of instances, is undeniably our most reliable means for the detection of foreign substances in the eye. A decided advantage is that many substances not suspectible to magnetism (and therefore not responsive to the needle and the magnet) are very plainly revealed by it—for instance, glass, though unfortunately, not wood. For the technique required when magnetic needles or the X-ray is employed for the purpose of detecting foreign bodies in the eye, the reader is referred to other and more appropriate portions of this treatise.

The foreign body should, when possible (especially if possible without too great disturbance of the intraocular tissues) be extracted. In no case, however, should the operator merely go "a-fishing" in the eye. In the case of substances susceptible to the action of magnets, such a removing instrument may be employed at times with very conspicuous success. In any case, however, even after the apparently successful removal of the foreign substance, the prognosis should be guarded, for, even in such cases, there may follow such cicatricial contraction that the eye, after a time, is absolutely worthless. If the foreign body is septic in character, the eye is nearly always lost, whether the foreign body is or is not successfully extracted.

Suppose that a foreign body is allowed to remain within the vitreous. What, then, is the prognosis? If the body be septic or oxidizable, the eye is lost almost as a matter of course. Sometimes, on the other hand, aseptic and non-oxidizable foreign bodies in the vitreous, are tolerated indefinitely, with or without encystment. As a rule, however, even bodies of this class sooner or later occasion iritis, cyclitis, and a plastic form of hyalitis, followed by contraction of the bands of exudate, and then sets in detachment of the retina, with, perhaps, a shrinking of the eyeball. The general health may suffer, and, as a last chapter in this melancholy history, there may follow sympathetic ophthalmia.

For the amount of damage done to the earning capacity by the

various forms of ocular injury, the reader is referred to a later section of this division of our chapter, entitled *"Visual Economics."*

Simulation of Ocular Injury or Disease.

By *simulation* we understand the feigning of an ocular injury or disease which does not at all exist; by the *false attribution* of an injury or disease, the assignment to an actually existent disease or injury of an untrue cause; by *exaggeration,* finally, the pretense that a certain injury or disease which does actually exist (whether the cause assigned be true or false) is of greater extent or severity than is really the case.

Closely related to these is *dissimulation,* or the pretense that an actually existent disease or injury does not exist.[67]

All these forms of falsification, excepting the last-named only, either with regard to the eyes or to any other organs, are very common—a fact that has been stated in almost every work on legal medicine with such a fullness of detail that the subject has actually been worn threadbare. However, to exemplify briefly with regard to the eye and with respect to simulation only: School children attempt to escape from their school-room duties by pretending that their eyes are painful.[68] Soldiers and sailors seek to avoid military service by pretending blindness, partial or complete, in one or both eyes. Pensioners have been known to simulate. Hysterical people, in order to excite either wonder or pity, often feign blindness. Finally, workmen in factories and mines, and passengers on, and employes of, railroad and steamship lines, often endeavor, after an accident, to produce on the mind of the examining expert the impression that their eyes are injured, though not the slightest harm has really been produced.

Of all the diseases of the eye which are feigned absolutely, *i. e.,* simulated—where the lie is, as it were, "made out of whole cloth"—the commonest are amblyopia and amaurosis. Next to these comes kopiopia, or the rapid exhaustion of vision; and, finally, there come concentric contraction of the visual field and scotomata. These four troubles, of course, when actually existing, can be exaggerated also, but, owing to the precision with which the condition of the visual apparatus can at the present time be determined, it is practically impossible to simulate any other affections of the eye than just these four. Almost all other diseases must show some actual pathological changes, in which event, of course, there is possible, in the way of falsification,

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[67]Simulation, false attribution, exaggeration, and even dissimulation have all been enormously increased in Europe, since the passage of the various "Workmen's Compensation Laws." For a notice of these, see, under the names of the different countries, the division of this chapter entitled, "*Ophthalmo-Sanitary Legislation.*"

[68]The Germans have a word, *Schulkrankheit,* by which they designate any feigned illness.

merely exaggeration or else the assignment to the pathological condition of an untrue cause.

Tests for the Simulation of Concentric Contraction of the Visual Field and Scotomata.—This sort of simulation, though very rare indeed, has yet been known to be practised. The commonest form is that in which it is pretended that there is a mere concentric contraction of the field. The contraction is generally feigned to be of high degree, as otherwise the injury to the earning power would be too slight to constitute a ground for heavy damages. The very existence of central scotomata, ring-shaped scotomata, and hemianopic defects, is wholly unknown except to experts. Possibly an expert might hope to simulate defects like these with a moderate chance for success. Expert or layman, however, the claimant should be examined on various days, or at least occasions, and the separate results should be written down and carefully compared. By taking the size of the field as a whole, and also the size of the various scotomata (if any are alleged to be present) at various distances, almost any malingerer with regard to the matters in question, can surely be exposed. It should be remembered, however, that in cases of hysteria (an affection that is often alleged to be of traumatic origin, as after a railway accident) the contraction of the field and the various other scotomata do not remain the same throughout the test, even in genuine cases.

Tests for the Simulation of Kopiopia.—Kopiopia is almost always due to errors of refraction, to paresis or paralysis of the ciliary muscle, to various affections of the extrinsic muscles, or to neurasthenia or hysteria. In all such cases, of course, the physical signs of the various disorders mentioned will be present, and there can be but little chance of error. Sometimes, however, rapid exhaustion of the eyes does really occur as an isolated symptom, and then the question of malingering or no malingering is very hard to answer. Repeated testing, from the nature of the affection, is of very little use. Continued observation is now and then serviceable; but, occasionally, actual detective work should be resorted to by those in charge of the defense. Sometimes a little investigation of this kind discloses wonderful matters. For instance, it may show that the supposedly kopiopic person is spending a considerable number of his hours in writing or reading. Again, a simulator will at times, for an attractive wage, consent to copy fine print for many hours daily, or nightly, especially if the place of working is such that he believes he will not therein be subject to damaging observation.

Tests for the Simulation of Amblyopia and Amaurosis.—Where amblyopia or amaurosis is feigned, the affection is almost always declared to be unilateral; nevertheless, for the sake of convenience, we

shall treat first of the very rare instances where the blindness is alleged to exist in both eyes. We depend, in such cases, very largely, on the presence or absence of the pupillary light-reaction. If the pupil acts quite well to light, the claimant is probably malingering. However, a word of caution is necessary as to this, for, in a very few instances of actual amaurosis *(i. e.,* where the lesion is situated high up in the optic tract) the pupillary light-reflex is retained unimpaired. On the other hand, one should always bear in mind that cases exist in which the pupil does not react to light, though light perception is present. Then, too, some persons possess the power of contracting or dilating the pupil at will, while, finally, the presence of posterior synechiæ accounts for the immobility of some pupils.

The way in which the pupillary light-reaction should be tested is this: The claimant, by ordinary diffuse daylight, is caused to face directly a window, and to gaze at a distant object, the while he holds a hand across the eye that is not under examination, in order to exclude the light therefrom. The examiner then first notices the size of the pupil in the eye that is being tested, and then excludes the light therefrom (by holding a hand across it) for as long as five or six seconds. On removing his hand, the examiner will find, in case the light-reflex is normal, that the pupil has considerably enlarged. The enlargement, or dilatation, remains for about a half a second, and then is followed by a very decided contraction. This contraction is succeeded by a moderate dilatation, and that by a still more moderate contraction, until at last the pupil becomes stationary in a condition of more or less moderate contraction, according to the intensity of the illumination. By the rapidity and the amplitude of these pupillary excursions the examiner decides as to whether the light-reflex is normal or abnormal.

All the conditions of the test, however, as above laid down, should be carefully complied with. Thus, if the examinee stand with his back, instead of his face, toward the window, the illumination may not be sufficient to affect the pupil visibly, even if the light-reflex be normal. Again, if the eye that is not under examination be not excluded from the light, the illumination that enters that eye will affect the pupil of the fellow organ through the so-called "consensual" light-reflex. Still further, if the examinee's gaze be not directed at a distant object, then the contraction of the pupil which results from, or at least accompanies, convergence and accommodation, will suffice to confuse the examiner.

To exclude the possibility of error through posterior synechiæ, the pupils of both eyes should be subjected simultaneously first to high and then to low illumination. In proper cases *(i. e.,* in young subjects and where there is no suspicion of glaucoma) atropin may be resorted to, and is generally conclusive.

Then, too, there are other tests. Dilatation of the pupils being an almost constant result of amaurosis, the absence of this symptom is exceedingly significant. True it is that dilatation can be produced artificially, *e. g.*, by means of atropin or cocain; but such a factitious mydriasis can easily be detected by the fact that, in nearly all such instances, the mydriasis is nearly or quite *ad maximum*. Complete dilatation *ad maximum* would indicate the combined employment of atropin and cocain.[69] Shrewd malingerers often use a weak solution of the drug, or defer the appearance for examination until the pupillary dilatation has somewhat subsided. *Schmidt-Rimpler's test* for the simulation of bilateral amaurosis is this: The examiner directs the patient to look at his own hand. A malingerer, especially if ignorant, will now and then look purposely elsewhither than at the hand, although, as a matter of fact, a person who has been blind, whether for a short time or for a long one, experiences no difficulty whatever in fixing either of his hands with his visual axes. The Schmidt-Rimpler test has been somewhat modified by Burghardt, who suggests that the claimant be requested to put out the forefinger of one hand, and then to touch that finger with the forefinger of the other hand. People actually blind, experience no difficulty in doing this. Quite important as a test for amaurosis (especially if declared to be of long standing) is the staring, fixed, unmeaning, look of the eyes, which is very soon acquired by those who are truly blind, and with which the experienced oculist cannot help being familiar. Not quite so important, and yet of some significance (because more likely to be overlooked even by a coached malingerer) is the short-stepping of the truly and totally blind, together with the upward turning of the face, and a generally "listening" expression. Repeated tests made with test-cards ending in lines of different-sized type on the different days, or occasions, of testing *(e. g.,* Snellen 40 on one occasion, Snellen 20 or 10 on another) will now and then suffice to expose the simulation of bilateral amblyopia, the malingerer believing that, on each occasion, he should, to be consistent, leave off reading at exactly the same number of lines from the bottom of the card. Further, it is always a ground for the greatest suspicion when the claimant, in reading aloud the test type, declares that he can read no further, although, thus far, he has made no mistake in identifying letters. A strictly honest reader will almost invariably miscall the hardest letters (for instance B and S) in one line, before declaring his total inability to read any of the letters of the next. Again, if he miscalls only certain letters in a line, and these are the easiest letters in

[69] "The mydriasis produced by the simultaneous action of atropin and cocain is the most considerable that can possibly be attained."—Fuchs, *Text Book of Ophthalmology*, New York, 1893, p. 259.

that line (for instance T and L), this is also ground for some suspicion. However, it should be remembered that even ordinary patients, who, for instance, are being tested for glasses, will now and then abruptly stop and declare their inability to read further, though, up to that moment, they had not miscalled a single letter. In the case of such patients, however, repeated urging will invariably bring about the reading of still finer lines of type and the customary irregular and gradual, instead of sudden and even, fading away of the power to read on. It is also well enough to note that the influence of astigmatism should be excluded before the failure to read easy letters while harder ones are recognized, should be regarded as suspicious. Not infrequently (in the case of unskilled malingerers, who, of course, constitute the largest class) the replies of the examinee, while he is being tested, are manifestly absurd. For example, he may allege that a weak lens, or even a flat glass, improves his vision greatly, or "magnifies" the letters very much. A + 1.00 D. S. "seems to feel good" to the eye, while a + .50 D. S. causes extreme pain. Threatening movements toward the claimant (accompanied by the greatest caution neither to make a noise nor to set in motion a current of air—noises and air-currents often alarming patients truly blind) will occasionally throw a claimant off his guard; and, in one instance, I detected a malingerer merely by "making a face" before him—the suddenly altered expression of the claimant's countenance being quite sufficient evidence that he had seen. A peephole through which the alleged amaurotic subject can be observed from a neighboring apartment is often an instrument of scientific precision, if not of dignity. Sometimes, from such a coign of vantage, the claimant will be observed to take up books and papers, and examine them critically. In very many instances, however, nothing suffices but protracted observation, especially in cases of simulated amblyopia, in which condition, of course, the presence or absence of mydriasis and the presence or absence of the pupillary light-reflex are very much less to be depénded on as tests for malingering than in cases of simulated amaurosis.[70]

Finally, it should always be borne in mind that the mere allegation of amaurosis or amblyopia is in itself a suspicious circumstance (particularly if unaccompanied by evidence of renal alteration) for the very simple fact that blindness, partial or complete, non-congenital, not due to refractive errors, or corneal, aqueous, or lenticular obstructions, and, furthermore, presenting no ophthalmoscopic changes whatever, are exceedingly rare. Occurring in connection with a claim for damages, an allegation of blindness, without the presence of a single supporting

[70]In fact, simulated bilateral moderate amblyopia is the hardest kind of important ocular malingering to expose.

objective symptom, is a proper ground for suspicion of very high degree.

The simulation of unilateral amaurosis and amblyopia is very much easier to detect than is the bilateral variety of simulation, although (as has been stated *supra*) it is much more commonly practiced. The following methods of detection have been employed:[71]

The Method of Cuignet.—Direct the claimant to read, at the same time to hold quite still both his head and the reading-matter. Insert a pencil vertically betwen the eyes and the book. If the patient continues to read uninterruptedly, he is undoubtedly seeing with both eyes, because, did he not see with one eye such letters as were quite invisible to the other (on account of the pencil intervening between that other eye and those letters) he could not read them. This test is by no means infallible, being absolutely worthless, indeed, in the case of all malingerers who have been thoroughly coached about it. Such malingerers can easily refuse to read all such words, or portions of words, as are overlaid by that particular "ghost-pencil" (there are, of course, two of these) which stands on the side of the sound eye. Further, the examiner must, in any case, be absolutely certain that both the claimant's head and the reading matter are kept absolutely unmoved. Otherwise, a claimant may seem to be malingering when, in fact (by moving his head or the book a trifle) he is really doing his best to read across the page continuously.

The Method of Alfred Graefe.—Have the claimant hold the professedly bad eye closed. Then set before the sound eye a prism in such a position that the thick edge thereof extends horizontally across the pupil. The claimant, of course, sees double—a fact he will readily admit, because, so far, the professedly unseeing eye has not been called in question. Then let the claimant uncover the "unseeing" eye, at the same time that the examiner slightly moves the prism in such a way that the sound eye cannot now possibly see double. If the patient still sees double, he is seeing with the eye which he before declared to be blind. The prism employed in this test must of course be strong enough (say 10°) to insure that double vision will necessarily result after the second eye has been uncovered—assuming, of course, that the second eye is possessed of sight.

This test has an especial advantage in that, unknown to the claimant, the visual acuity of each eye can be accurately determined. This is accomplished by having the claimant read aloud first one, then the other, of the twin images.

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[71]A rather large number of tests should be familiar to the expert, because some tests may easily enough be rendered useless by reason of the claimant having been very thoroughly coached concerning them.

The test is also carried out in a simpler form. The examinee is permitted to look with both eyes. The physician places a 10° prism, base up or down, before the sound eye, and, if the claimant admits to seeing double, he is seeing with the alleged blind eye, as well as with the sound one. The difficulty is, however, with this simplified form of the test, that the claimant, because his alleged blind eye is manifestly under examination, will not invariably confess to seeing double. He is much more likely to do so with the test in the regular form.

The Crossed Diplopia Test.—This also is a test carried out by means of a 10° prism. Place the prism, base out, before the alleged blind eye. If that eye sees, it will make an excursion inward, involuntarily, for the sake of single vision. Of course, if it does not see it will not perform this movement.

Method of Vieusse.—On a plain stereoscopic card are fastened two wafers of different color—one red, for instance, and the other blue—at a distance in the case of each wafer, of ½ centimeter from a vertical line dividing the card into halves. When so small a distance—only 1 centimeter—separates the wafers, the wafer which is on the right side of the card appears, when the card is looked at through a stereoscope, to be on the left, and the wafer which is on the left half of the card appears to be on the right. The card is placed in a stereoscope, and the instrument handed to the claimant with the request that he look at the card through the instrument and inform the examiner as to what it is that he sees. If he admits that he sees both wafers, then, of course, he is seeing with both eyes. If, on the other hand, he confesses to seeing one wafer only, he is asked to state the color of that wafer. He will almost certainly, if malingering, name the color of the wafer which appears to be on the side of the sound eye. By so doing, he of course, unmasks himself completely, for the wafer that appears to be on the side of the sound eye is the one which is seen by the eye that he alleges to be blind.

Perhaps a better way is to have a horizontal line on one of the halves of the card, a vertical line on the other, these lines occupying such positions that, when seen through the stereoscope by a pair of sound eyes, they appear to form a cross. If, then, a person really blind in one eye, looks through the instrument at this card, he will see either the horizontal line only, or else the vertical line only. If he admits to seeing a cross, he is malingering, of course.

The Method of Harlan.—Have the claimant cover with his hand the alleged unseeing eye. Place before the sound eye a + 6.00 D. S. glass. This eye is now artificially myopic, and can read, (assuming that the eye is emmetropic naturally) fine print at a distance of 6½ inches at the very farthest. Place a card of fine type very close to the

eyes, and have the claimant release the injured organ. Ask him to read aloud, and then, as he does that, slowly remove the card from the eyes, until a distance greater (to be perfectly sure, some inches greater) than 6½ inches, is intervening between the claimant and the card. If the claimant still reads, he is doing this solely by means of the eye which he had previously declared to be blind.

This test is also employed in a slightly different way. The claimant, when the test is applied in this modified form, is not requested to cover the alleged bad eye at all, but, at the very outset, there is placed before both his eyes a trial frame containing a + 6.00 D. S. lens for the sound eye and a flat glass (or, what amounts to the same thing, a + .25 D. S. lens) for the other. The claimant is then requested to read the distant types. Believing that he has about the same sort of glass before each eye, the examinee very often proceeds to read, thus, of course, demonstrating the fact that he is seeing with the eye which he alleges to be blind.

Method of Jackson.—Place before the eye supposed to be blind a + 4.00 D. S. lens and before the sound eye a + 2.00 D. S. The *punctum remotum* of the first eye will now be 25 centimeters; of the other, 50 centimeters. Hand the claimant a card of fine type, and ask him to read. If he selects as his reading distance 25 centimeters, instead of 50, he is malingering.

Method of Snellen.—This method requires the possession of test-types alternately red and green upon a black ground, and a pair of spectacles in which one glass is green, the other red. Through the red glass only the red letters, not the green, are visible; and, correspondingly, through the green glass, only the green letters and not the red ones, can be discerned. If the claimant reads all the letters indiscriminately, he is reading with both eyes.

Method of Nettleship.—Instil one drop of a 2 per cent solution of atropin into the *sound eye*—preferably after cocainization. Then bandage *both* eyes for one hour. Place in the claimant's hand a card of fine type, remove the bandage, and request him to read aloud. If he reads, he accomplishes that feat by means of the blind eye. This is theoretically an excellent test, but, in practice, I have found it difficult of employment, because the claimant not infrequently objects to having "medicine" put into his sound eye. Homatropin I have also found much preferable to atropin, because, the claimant being naturally somewhat hostile to the examiner, is apt to view with much alarm the week of actual blindness in the sound eye resulting from the use of atropin. There is also ever present, whether homatropin or atropin is used, the remote possibility of relaxing in this, the sound, eye a long-existing spasm of the ciliary muscle covering a high degree of hypermetropia,

and then of the spasm not returning when the otherwise transitory effects of the atropin have passed away. In such a case, of course, the hostile claimant can hardly be convinced that he has not been seriously injured in the sound eye by the examiner, and a suit against the examiner in which the defendant in the original suit (or claim) may or may not be joined (according to whether he can or cannot be regarded as a principal, under whom the examiner was acting as agent) may follow. In any case, to use this test successfully, the examiner must make sure (preferably after the claimant has admitted his ability—or denied it—to read) that relaxation of the ciliary muscle in the sound eye and consequent inability of that eye to read fine type has actually occurred.

In addition to these more particular methods, almost any one of which will suffice in the vast majority of cases, the state of the pupil as to light-reflex and dilatation should be carefully interrogated. And, by the way, when testing the light-reflex in a case of alleged unilateral amaurosis, we should never forget to examine the consensual light-reaction, since this is a means of determining whether the non-response to light in the pupil of the alleged bad eye, is, or is not, due merely to posterior synechiæ. The way in which to test the consensual light-reflex is this: The pupil of the eye to be tested is alternately exposed to and excluded from the light, while the effect of so doing is watched in the second eye. If the second eye (being itself healthy) does not respond to the alternate screenings and exposures of its fellow, then the absence of the light-reflex from that fellow eye is not due to posterior synechiæ. It is to be observed that, in unilateral simulation, as well as in bilateral, the malingerer not infrequently resorts to the factitious mydriasis producible by means of atropin or cocain. In this connection it should be remembered that, when only one eye has been atropinized, the pupil of the other eye is narrower than normal, because of the consensual light-reflex being excited unduly by means of the unaccustomed quantity of light which enters the atropinized eye. Sometimes the pupil of the second eye is found abnormally enlarged, because of some of the atropin solution (or at times even some of the tears from the atropinized eye) having been inadvertently introduced into the admittedly sound eye. The admittedly sound eye may also present a dilatation due to the fact that so much of the atropin solution has been used in the professedly amaurotic eye that the general effects of the drug (which include, of course, a dilatation of the pupils of both eyes) have been evoked. In unilateral malingering, however, as well as in bilateral, it may, in case the claimant be a man of shrewdness and understanding, become absolutely necessary to resort either to espial or to protracted observation—the claimant, after a few weeks, or while

away on a visit, neglecting to keep the pupil of his "blind" eye dilated. Threatening motions (care being taken, as before, to guard against the production of noise and air currents) and also the making of faces can be employed in unilateral malingering, as well as in bilateral, by first placing a bandage over the sound eye, or directing the claimant to hold a hand across it. One of the best of the threatening motions consists in making as if to poke a finger into the eye.

The False Attribution of Ocular Injuries or Diseases.

The false attribution of ocular injuries or diseases (by which we mean, as before stated, the assignment of an untrue cause to a real injury or disease) is, like simulation, very common. On the other hand, unlike simulation, it is often accompanied by exaggeration. (Exaggeration can also exist without false attribution). In fact, false attribution is much more common than simulation, for the reason that this particular form of falsification can be applied to a vastly wider range of injuries than can the latter description of malingering. Simple simulation, indeed, is, as a rule, from its very nature restricted to kopiopia, to concentric contraction of the visual fields and scotomata, and to amblyopia and amaurosis, while fraudulent attribution can find full play and opportunity in well-nigh every conceivable form of ocular incapacity, and, moreover, almost always has objective symptoms to give it plausibility.

To take a few examples. A man is afflicted from childhood with strabismus. After a railway wreck, he alleges that certain injuries received by him at the time of the accident are responsible for the crossing of the eyes. A woman has congenital colobomata of the irides. After falling through a defective sidewalk she declares that since the injury, she has had no sight whatever, and she offers the colobomata as objective evidence that her eyes were actually injured on the occasion of the fall. A man afflicted with detachment of the retina due to extreme myopia, seeks, some day, to ascribe his diseased condition to the undue force with which he was ejected from a room in which, against the protests of the proper occupants, he was endeavoring to sell books. A man on whom a charlatan was "operating" for the removal of a "cancer" from the eyelid, received upon the pupillary area of the cornea a drop of some sort of acid. A dense leucoma formed, with the total abolition of qualitative sight, and, some six years later, the victim sought to prove that the corneal opacity had been developed in consequence of an injury received in a mine. Such are a few of the almost infinite forms and varieties which fraudulent attribution assumes in connection with injuries to, or disease of, the eye.

In discussing these various forms and varieties we divide our subject into:

1. Injuries affecting the eyelids and eyebrows.
2. Injuries affecting the conjunctiva and cornea.
3. Injuries affecting the iris.
4. Injuries affecting the lens.
5. Injuries affecting still deeper portions of the eye.

1. *Injuries Affecting the Lids and Eyebrows.*—With respect to the false assignment of causes in the case of injuries to these parts, it is always necessary, of course, to consider the nature of the wound or wounds in relation to the cause assigned. It will often occur that the cause assigned could not possibly account for the appearances produced. On the other hand, the examiner must be cautious not to declare as impossible a cause which, after all, is really the true one. Thus, as stated already, under the heading of *"The Commonest Injuries With Which the Ophthalmo-Surgical Expert Has to Deal,"* we mentioned the very deceptive appearance which is often produced by contused wounds of the eyebrow, these wounds not very infrequently seeming to have been produced by a knife, axe, or other cutting instrument, though produced in fact by the fist. We also dwelt upon the great importance attaching to a correct distinction between contused wounds and incised wounds in this portion of the body, persons often being accused of assault with a deadly weapon, or intent to kill, when, as a matter of fact, they are wholly innocent of such a high-grade crime.[72] The distinction is easily made, as may be recalled, by means of the following signs: 1.—A contused wound is the far more likely to present an areola of ecchymosis. 2.—Under a lens, the walls of a contused wound are seen to be not actually smooth, but more or less ragged. 3.—While an incised wound shows all the tissues divided just as deeply down as the wound reaches, a contused wound mimicking an incised wound, shows some of the fibers of the more resisting tissues undivided, while others, deeper down in the wound, are severed. 4.—The really contused, though apparently incised, wound is generally more extensive (longer) at the bottom than at the surface, while the really incised wound is apt to possess a so-called "tail" both at the beginning and at the end—in other words to be of greater extent in the skin than in the deeper tissues. This distinction is due to the fact that, in the really incised wound, the inflicting instrument cuts from without inward, whereas, in the case of a wound of the contused variety, the incising instrument—the bone—cuts from within outward.

It is always worth remembering that not infrequently a claimant is honestly mistaken as to the nature of the weapon with which his

[72]It is owing to the great importance of this distinction that the matter is given some treatment under the present head as well as under that of *"The Commonest Injuries with which the Ophthalmo-Surgical Expert has to Deal."*

wound was produced. Thus, he may, reasonably enough, have seen a flash from a ring or a cuff-button, worn by the assaulter, and, later, observing the apparently incised nature of the wound, have come to the conclusion (more or less unconsciously perhaps) that what he has seen was the flash of a knife. He will then, almost to a certainty, declare (and of course with the utmost honesty) that he saw a knife in the hand of his assailant, or even, in case he happen to be possessed of a rather active imagination, that he has seen the assaulter "draw" a knife.

As an instance of the opposite state of affairs, *i. e.*, when it appears from the look of the wound that a knife could hardly have been employed, although, as a matter of fact, a knife was the actually inflicting instrument, we refer to the rather rare instances where a single sweep of a knife across the eyelid has occasioned a zigzag wound, presenting a torn—the so-called "lacerated"—appearance. This phenomenon is due to the fact that the knife, before it cuts, stretches out the very extensible skin before it and then parts the tissues. When the skin goes back into place, the appearance is that of a V or a Z, as if a hook or some such object had engaged in the skin of the lid and then torn it in two or more directions, or perhaps have engaged more than once in the skin. In the case of wounds like these, the question sometimes takes the form, not as to whether a knife was the actually inflicting instrument, but as to whether a knife which is admitted to have been employed for one single stroke, was not really used again and again, the answer to this question having an important bearing on the legal inquiry as to whether (in case the user of the knife was acting in self-defense) the self-defender did not, by the employment of "excessive force," become in his turn (from the legal viewpoint) the aggressor.

Wounds of the eyelid are sometimes produced voluntarily, with the intent to ascribe the injury to an accident or an assault ("putative," or "self-inflicted," wounds) and then are almost always superficial in character, the lips of the wound, however, being kept apart sometimes, during the process of healing, in order that a large and showy cicatrix may result. Almost invariably, in such instances, the factitious wound has been resorted to in order to give objective evidence to a claim of traumatic amblyopia or amaurosis. The superficial character of the scar, together with the various tests for simulated amblyopia and amaurosis, as above set down, will almost invariably reveal the fraudulent character of the claim.

Ecchymosis, being a very common accompaniment of contused wounds of the eye, affords at time important evidence in connection with fraudulent claims. One should ever bear in mind that an ecchymosis of these parts is at first violet, blue-black, or livid red in color: in a day or two, green, then yellow, then lemon-yellow, finally whitish-

yellow and normal. One should also remember that, in ecchymosis of the upper lid, the darkest portion of the discoloration is always, after the lapse of a few hours, at the lower lid-margin,[73] the changes in color above noted showing earliest at the upper boundary of the discolored area. It is, of course, impossible to determine the precise age of an ecchymosis from its color; yet, in many instances, the hue of the part affords irrefragable evidence of a fraudulent claim. Thus, for example, if a claimant with an ecchymosis in the livid, or blue-black, stage, especially if the darkest part (in the upper lid) had not yet settled down to the lower lid margin, should allege that this discoloration had been produced a week or thereabouts before, we should know to a certainty that he was "mistaken."

Emphysema, with crepitation, of the lids and orbit can be produced by injecting air into the loose areolar tissue of these parts, and a simple tumefaction without crepitation, lasting for several days, can be produced (as every ophthalmo-surgical expert knows) by the hypodermic injection of solutions of cocain and other substances—and, in some instances, even of plain water.

Ulcers in the skin of the eyelids can easily be manufactured by means of the various irritants, corrosives, and vesicants. The most commonly employed are: chewed tobacco, bruised garlic, nitric acid, corrosive sublimate, and quicklime. I have even been informed that a miner who was slightly burned in a mine explosion actually burned the lids of both eyes, as well as other portions of his face, by means of a candle flame, applied by his own hand, in order to increase the extent and severity of the ulcers that followed, and thus the amount of probable compensation to be received by him.[74]

The injuries and discolorations produced by the different sorts of acids and alkalies are worth recalling in connection with the fraudulent or mistaken attribution of injuries. Thus, sulphuric acid turns the

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[73] A phenomenon due to the fact that the extravasated blood "settles" down through the loose interspaces of the palpebral areolar tissue till it reaches the lower lid margin. About the body generally, the darkest portion of an ecchymosis corresponds pretty closely to "the point of greatest violence"—*i. e.*, of greatest crushing, or contusing, force—a state of affairs which continues as long as the ecchymosis remains visible.

The extravasated blood not infrequently seeps beneath the skin covering the dorsum of the nose, and so on into the loose areolar interspaces of the lids of the opposite eye (the falsely denominated "sympathetic" ecchymosis). The skin of the nose being very thick and opaque, the ecchymosis is, in that part, invisible, and hence it appears that an independent ecchymosis of the opposite eye has taken place, perhaps as the result of a fracture. This phenomenon of an apparently independent ecchymosis in the opposite eye, is so common, after an enucleation of the eyeball, as to be familiar to all ophthalmic surgeons.

[74] It may not be uninteresting to note that the artificial production of ulcers is probably "the earliest, as it has been the most extensively excited disease." Gavin, *Feigned Diseases*, London, 1843, p. 332.

skin brown; nitric acid, yellow; while hydrochloric acid either does not stain it at all or turns it very faintly yellowish or yellowish-brownish. Acids (especially "vitriol," or sulphuric acid) were in former days frequently (they are even yet occasionally) "thrown" by women into the faces of their rivals, with the almost invariable result that the skin of the eyelids and eyebrows was cauterized, and a suit for damages or a criminal prosecution (not infrequently both) was now and then the result. Acids, too, as already stated, are used for the artificial production of ulcers and cicatrices, on which conditions a claim for damages can be based. Alkalies discolor the skin at first white; later, red or dark-brown.

To distinguish the so-called "burns" produced by such escharotics from burns produced by heated substances—a distinction sometimes necessary—the following points are useful:

(a) If the injury be recent, a chemical test can be made, and the presence of sulphuric, hydrochloric, or nitric acid, or other escharotic liquid on the skin can easily be determined. If any of the escharotic have been spilled upon the clothing, or other surrounding objects, the chemical test is still more applicable.

(b) Scorching of hairs in the neighborhood of the injury, points to a heated substance of some sort as the almost certain origin thereof, for escharotics do not affect the hairs of the nearby parts.

(c) Blisters, which are almost always present after injuries produced by heated bodies, are never produced by the action of escharotics.

(d) After the action of an escharotic there is never capillary congestion (erythema) of the skin surrounding the injured area. This phenomenon occurs invariably after burns by heated substances, if of more than the first or second degree, unless the injuries are followed so promptly by the death of the injured person that this symptom of reaction does not have time to appear.

(e) Burns by heated solids can generally be distinguished from burns by heated liquids, as well as from the results of escharotics, whether liquid or solid, by the fact that the eschar which is produced by an escharotic, or by a heated liquid, is soft and moist and yellowish, instead of hard and dry and dark, as after an injury produced by a heated solid.

A very important subject in connection with the fraudulent attribution of injuries, is that of scars in the skin of the lids, especially with relation to their age, for, sometimes, the false attributor alleges of an ancient cicatrix that it is recent, or, on the other hand, of a recent cicatrix, that it is old. Such people also not infrequently cause cicatrices to be artificially removed (so far at least as this is possible) and, on

the other hand, declare that scars which formerly existed have spontaneously disappeared.

At the very beginning it should be thoroughly understood that, in the skin of the eyelids as in other portions of the body, very superficial burns or wounds, involving only the epidermis or the superficial part of the derma, produce no scar at all or else a scar that promptly disappears completely. We may also say—for the sake of completeness, since the matter is otherwise unimportant—that a punctured wound produced by an instrument of the nature of an extremely fine needle and consisting merely in the separation of the anatomical elements of the skin and underlying tissues without the production of a bloody tract, produces absolutely no cicatrix whatever of any sort or kind. In the case of a punctured wound accompanied by the production of a bloody tract (however slight the hemorrhage may be) there results invariably a scar. This scar, at first, is merely a reddish point. Later, it becomes of a dark brownish color, and increases a trifle in area (as any one has seen in the case of the punctate scars produced by sutures in the skin of the lid). Still later, the scar begins to bleach, and, at the same time, to contract, till, finally, the color is a pearly-white and the area very small indeed. May such a scar disappear entirely? In my opinion it may, practically at least, whatever it may do theoretically. Linear wounds and wounds of square extent, result in cicatrices, invariably. Generally speaking, too, such scars are indelible unless tampered with. However, scars in the skin of the eyelids disappear oftener and more completely than in almost any other portion of the body. Operations, furthermore, may be resorted to which change the appearance of all such scars, or even (when the cicatrices are not too extensive or too deep) remove them to such a degree that, at least for all practical purposes, the condition of the skin is exactly the same as though the scar had never come into existence. If the scar is too deep, the skin can never be restored quite to its former condition of free extensibility (permitting, in fact, of far withdrawal from the underlying parts) and, if too extensive, the skin will, after the operation, be shortened and tight-looking, devoid, in fact, of the folds and wrinkles displayed by the skin of the corresponding lid of the other eye. Sometimes, however, by an operation on this other eye, a symmetrical and therefore very deceptive condition indeed can be produced. Extremely accurate examination is necessary in all such cases, and a magnifying glass is often helpful.

Just at what age of the wound the different color-changes occur in a scar cannot be determined precisely (however devoutly such a consummation might be wished) even for a particular case. In general, however, cicatrization is complete *(i. e.,* the scar has completely *formed)* in about four days after a simple, linear, and non-infected incised

wound, whose lips have been appropriately approximated. Wounds of superficial area heal more slowly than incised wounds, and wounds in aged persons or diseased subjects much more leisurely than in the young and healthy. The pink, or reddish, *young* cicatrix turns to the older brownish variety in about eight weeks, or perhaps a little more. In from two to three months additional, the cicatrix has bleached and taken on the well-known appearance of an ancient cicatrix—an appearance which, under normal circumstances, is just about permanent.

All cicatrices, however, whatever their original shape, in the eyelids as elsewhere about the body, tend to become more and more linear in form. Then, too, ancient cicatrices, in the skin of the eyelids as in the body generally, get a trifle smaller in area and a little thicker, as they increase in age, excepting in children only, in whom they actually enlarge in area as well as in thickness. When, however, children reach adult life, their ancient cicatrices begin to contract.

Scars are much more apparent in brunettes than in blonds, and they are also said to stand out much more plainly in negroes than in Caucasians, by reason of the fact (as alleged) that a cicatrix never acquires a *rete mucosum* even in the negro and hence is forever devoid of coloring matter even in the African race. In my personal experience, however, the statement has not held good. I have seen in negroes numerous scars that were very deeply pigmented, and, in the eyelids, many that required the most careful observation for their detection.

Scars otherwise imperceptible may often be brought out plainly (in the white race) by smart friction of the lids, a procedure which reddens the skin and makes the white scar plainer by the contrast. A lens is always useful.

Burns produced by explosions of gun-powder sometimes have to be distinguished from those produced by fire-damp explosions, which occur so frequently in mines. The necessity is all the greater from the fact that, in each of these kinds of burns, the hairs of nearby (possibly also distant) parts are invariably scorched: hence no means of distinction is afforded by the presence or absence of scorched hairs. However, the distinction is very easily made by the difference in the tattoo marks in the skin which each of these forms of explosion produces. The distinction is made in three ways: 1.—The coal tattoo is blacker, and less violet, in color, than the dotting made by gun-powder. 2.—The coal-dust spots vary greatly in size, while the dots from gun-powder are almost absolutely uniform. 3.—Particles of gun-powder, or of coal, can be picked out of the skin, and their nature determined chemically.

2. *Injuries of the Conjunctiva and Cornea.*—In *traumatic conjunctivitis* the question is nearly always as to whether or not the inflammation of the conjunctiva is traumatic or non-traumatic in origin. How,

then, can a distinction be established between a traumatic conjunctivitis and one not traumatic? If the conjunctival inflammation be alleged to have been produced by a powder or a fire-damp explosion, there will nearly always exist in the conjunctiva (also, perhaps, in the skin of the lids) the same, or a very similar, bluish or blackish tattoo which is produced in the skin by such explosions. There will also exist the indications of a burn, namely, shortening, thickening, wrinkling or puckering, and opacification of the conjunctiva, as well as adhesions (symblepharon) between the eyeball and the lids. Burns by acids and alkalies also leave conjunctival cicatrices, together with, almost invariably, the characteristic stains upon the skin. Any considerable quantity of nitric or sulphuric acid in the eye causes deep sloughing, which means, of course, perforation of the eyeball.

Conjunctivitis, alleged to be due to trauma, is occasionally manufactured by the intentional introduction into the conjunctival *cul de sac,* of tobacco juice, particles of sand, bits of lime, drops of lemon-juice, and solutions of bluestone or corrosive sublimate. Foreign bodies of considerable size and irritating properties have been discovered, neatly bestowed within the folds of the upper conjunctival commissure, to the presence of which was due a spurious conjunctivitis; it is therefore desirable, in all suspicious cases of traumatic conjunctivitis, to examine carefully the recesses of these folds.

Traumatic pterygium occasionally occurs as a result of injury to the conjunctiva and cornea, and, now and then, a claimant for damages alleges that a pterygium of the ordinary spontaneous[75] variety was produced by an accident for which he seeks to hold some company or individual responsible. The distinguishing points, however, between these two varieties of pterygia render impossible the acquiescence by any honest expert in such a mistaken, or fraudulent explanation of the origin of the growth. The central point of distinction lies in the fact that a pterygium of traumatic origin (customarily so designated) does not possess a pterygial canal, or epithelium-lined passage which lies between the growth and the eye at the sclero-corneal junction. Further, a pterygium of traumatic origin is often adherent more or less extensively to the eyelid, thus giving very plain evidence as to the nature of the origin of the growth. Still further, a traumatic pterygium is less transparent, thicker, and also less freely movable on the sclera. Then again, a false or traumatic pterygium is seldom situated (as is that of the ordinary variety) symmetrically astride the horizontal meridian of the eyeball—in fact not only is it often more above or more below this line,

[75]All the so-called non-traumatic, or spontaneous, pterygia, however, probably originate in slight, repeated traumata. See on this head an article by the present writer, entitled "Pterygium," in the *Ophthalmic Record,* Vol. 14, No. 10. Oct., 1905, p. 465.

but it is not infrequently situated wholly above or wholly below the cornea. Finally, a traumatic pterygium is never progressive, while the ordinary, or true, pterygium may or may not be so.

3. *Injuries of the Iris.*—The salient points to be remembered in connection with the fraudulent or mistaken attribution of injuries to the iris relate to the fact that many anomalies of the iris, which seem to the inexperienced observer to be traumatic, are really congenital. These matters were considered somewhat fully in a former division of this chapter, but here it may be well to remind ourselves of the following extremely important characteristics of certain congenital anomalies.

a. The threads of a persistent pupillary membrane (often mistaken for posterior synechiæ) do not arise (as the p. s. do) from the margin of the iris or its posterior surface but from a point on the anterior surface of the iris, a trifle removed from the pupillary margin. Also, under atropin, these threads prove very elastic.

b. Congenital coloboma of the iris can be distinguished from traumatic coloboma and from retroversion and retroflexion by the fact that, in a congenital coloboma, the sphincter iridis continues into and round the gap unbrokenly. Further, it is almost (though not quite) always situated below, and is frequently associated with coloboma of the choroid, corpus ciliare, and lens.

c. Heterophthalmos, corectopia, and polycoria, are liable to be mistaken by the ignorant for the results of traumatism, but a person accustomed to examining injured eyes could hardly be imposed upon to that extent by such plainly congenital anomalies.

4. *Injuries of the Lens.*—A claimant now and then attributes to an accident or an assault a condition of the crystalline lens which is really congenital or the result of some spontaneous disease.[76] Thus, a congenital, or a senile, or a diabetic cataract may falsely be attributed to a cause for which some corporation or individual could be held responsible in damages. A traumatic cataract, however, is generally produced by the action of a penetrating instrument (this, sometimes, is a foreign body which remains) and, in such a case, the tract whereby the inflicting instrument made its way through the ocular tissues to its point of contact with the lens, is easily enough determined. In such a case there can be no doubt as to the origin of the cataract. Even if the instrument were very small, for instance a delicate needle, no doubt could exist if lenticular matters were being extruded into the aqueous through a rent in the capsule. Sometimes, however, a

[76]It would seem, according to Woodward, that traumatic cataracts had been known to be "self-inflicted," or "putative." Thus that writer in Witthaus and Becker's *Medical Jurisprudence, Forensic Medicine, and Toxicology*, 1896, Vol. III, p. 28: "Cataract has been intentionally produced by thrusting a needle or a knife-blade through the cornea into the crystalline lens."

mere contusion, or concussion, of the eye suffices to originate a cataract, and then the distinction between such a lenticular turbidity and a congenital or senile cataract may become a harder matter. Even in such a case, however, the distinction is generally sufficiently obvious on account of the extremely regular and symmetrical appearance of congenital and senile opacities, while the lens turbidity produced by traumatism of any sort is nearly always irregular. Then, in addition, in congenital cataract, the eye as a whole is apt to be very badly developed. The claimant's history will almost always, unless he be an infant, conclusively settle the matter.

Luxation and subluxation of the lens may be congenital or the result of disease, as well as produced by trauma. When occurring as the result of disease, the pathological condition consists of softening and wasting away of the zonula, which, in its turn, is occasioned by high-grade myopia and choroiditis. Then, too, a spontaneous variety of dislocation occurs in hypermature cataracts as a result of overstretching of the zonula. The various concomitant conditions, of course, point out the nature of these spontaneous dislocations, while, where the lens is congenitally out of place, the dislocation is almost always upward, the lens is small in size, the eyeball as a whole is apt to be poorly developed, and, finally, there exists a life-long history of inferior vision.

5. *Injuries Affecting Still Deeper Portions of the Eye.*—Injuries of the vitreous, the sclera, the choroid, the retina and the optic nerve, are also now and then attributed to suppositious causes, but, in these cases, the ophthalmic expert has little that is special to guide him; he can merely employ his knowledge of ocular pathology in general.

Exaggeration of Ocular Injuries and Diseases.

Tests for Exaggeration.—Exaggeration of the effects upon the sight of various actually existing injuries and diseases (whether or not such injuries and diseases are attributed to untrue causes) can generally be detected by noting the nature and situation of the various pathological lesions, and also by means of the tests for simulation (laid down some distance *supra*) since the tests for simulation are useful in exaggeration. Of especial importance among these tests is that of Alfred Graefe, because thereby the examiner may, unknown to the subject of the test, determine accurately the visual acuity of each eye. It should be remembered that an actually existing amblyopia may be so exaggerated as to seem an amaurosis, and also that even an actual amaurosis may be exaggerated by the contention that it has been in existence for a longer time than is really the case. In the latter state of affairs, if the amaurosis be alleged to be of very

long standing, the examiner will, of course, be careful to note whether, as yet, the eyes have taken on the "staring, fixed, unmeaning" look of eyes that are truly blind, as well as whether the applicant himself has acquired the short steps, the upturned countenance, and the generally "listening" expression.

Dissimulation of Ocular Defects and Diseases.

This form of falsification is not very common in America. In Europe, however, especially since the passage of the various "Workmen's Compensation Laws" (which render employers liable for injuries to their workmen, irrespective of all such technical matters as assumption of risk, contributory negligence, etc., etc.) the number of dissimulators has increased enormously. This consequence arises from the fact that, when an employer is obliged, in effect, to insure his workmen, he desires to know to a certainty before he grants employment to any given man, that the applicant is possessed of sufficient visual power tö keep from being hurt. He stands, in a word, where subject to such laws, in much the same position as an accident insurance company or a life insurance company. For this reason, it is said, the Workmen's Compensation Laws, beneficent as they are in many respects, have entailed much hardship on workmen already defective. Defective workmen, in fact, find great difficulty in securing employment where such laws as those in question exist. And even in America, dissimulation is practised now and then, not only by those attempting improperly to effect accident or life insurance, but also by persons endeavoring to secure employment with railway or steamship lines, to be admitted to the army or the navy, and even to contract advantageous marriages.

Our chief solicitude should be, when testing the eyes of those who may be dissimulators, not to rest content with a mere determination of the central visual acuity. Thus, a person's central vision may very well be in each eye 20/15, or above normal, and yet his peripheral vision be very poor indeed. Again, with excellent central sight, he might be harboring a foreign body in the vitreous, or be suffering from chorio-retinitis, peripheral lenticular opacity, or eccentric ulcer of the cornea. Futher, he might be afflicted with mydriasis, with or without paralysis of the accommodation, or, if tabetic, with Argyll-Robertson pupils.[77]

[77]Finally, he might be afflicted with an excellent memory, in support of which paradox I cite the case of a gentleman who, a number of years ago, desired that I permit him to copy the four smallest lines, together with the largest, of each of my Snellen cards. He intended, he said, "to take an examination for a railroad," and, being "short" four lines, or thereabouts, to commit the top line and the bottom four to memory. Thus fortified, he could read the bottom four lines of any card, out of his memory, whenever he saw

Visual Economics.

An expert witness is often required to furnish to the jury certain facts and principles in accordance with which that body may be able to determine the amount of damages which ought to be awarded, or, as the law expresses the matter, "to assess the damages." We have already seen that, in assessing damages in a personal injury case, a jury may allow for matters such as: (1) necessary and reasonable expenses—hospital fees, for example, and nurses' and doctors' bills; (2) loss of time; (3) pain and suffering; (4) disfigurement; (5) reduction of the earning capacity. This latter is often, perhaps generally, the most important item in the list. Now it so happens that, with respect to injuries of the body generally, either the actual reduction in the earning capacity must merely be guessed at in the most haphazard fashion, or, really, cannot be estimated at all. In the case of the eye, however, the matter is different. When an eye is injured, an experienced oculist can (as a rule to which there are scarcely any exceptions) determine the *quantum* of injury *(i. e.,* the reduction of earning capacity) with well-nigh mathematical accuracy. Nevertheless, owing to the fact that a proper formula had not yet been worked out, the accurate estimation of the loss of earning power was, even in a case of ocular injury, by no means possible until very recent years. Now, however, thanks to the labors of Zehender[78], Groenouw[78], Heddaeus[78], Jatzow, Josten, Hansel, and, most of all to Magnus[78], of Breslau, and Würdemann[78], of Seattle, the subject of "Visual Economics" has been developed into a useful and, everything considered, extremely accurate science.[79]

Passing by the formulas of Zehender, Groenouw, and Heddaeus, which have been supplanted entirely by that of Magnus and Würdemann, we will state the latter formula at once, and then proceed to an explanation of the means whereby that formula is ophthalmologically and mathematically deduced.

The Formula Itself.—The complete formula, then, for the ocular earning ability, is as follows:

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the top one. The company-doctor and I, he said, had just the same identical cards.

[78]These men have proposed formulas; the others mentioned have proposed no formulas, but have rendered yeoman service in connection with "Visual Economics" nevertheless.

[79]The classical work on the subject is "*Visual Economics*," by Magnus and Würdemann, Seattle, Wash., 1902. So exhaustive and so accurate, in fact, is this little book of 115 pages, that but little remains for subsequent writers on the topic of "Visual Economics" to do, but to amplify or to abridge that epoch-making book. The reader who desires to study the subject thoroughly, is, therefore, referred to the book in question: all that is here attempted is an abstract thereof. Moreover, whenever possible within the limits of our chapter, we permit the authors of that treatise to speak in their own words.

$$E = C\ (\max.)\ \sqrt{P}\ \sqrt[4]{M}\ \sqrt[x]{\frac{C_1 + C_2}{2}\sqrt{P}\ \sqrt[4]{M}}.$$

Now, while this formula, at first sight, appears a little complicated, it is really rather simple, as will readily appear from the forthcoming explication. Moreover, as Magnus and Würdemann state[80], "If we try to simplify the complicated relations they could only be forced, and an arbitrary speculation substituted for its [the formula's] own composite character." Then, too, this formula is not by any means supposed to be presentable to a jury, but only its results; as, for instance, that the earning power of the plaintiff in the particular case at bar has been reduced, in consequence of the injury of which he complains, by 42 per cent. Exactly what amount this percentage of reduction would be equivalent to, expressed in dollars and cents, would be for the jury to compute, and, indeed, they ought to be equal to so very simple an arithmetical task.

The Method Whereby the Formula Is Obtained.—The formula in question is based upon the supposition (which surely is not refutable) that "injuries affecting the vision have a direct detrimental effect upon the earning capacity." From this very simple proposition there follows another, which is almost equally self-evident, namely, that "the earning ability * * * is practically synonymous with the visual earning ability." True it is that, in certain occupations, "such as banking" and "some mercantile pursuits and professions where knowledge may be assimilated through the eyes of others * * * some specially well placed and talented individuals may continue to be economic factors;" but these are great exceptions, and, in the vast majority of cases, the blind are "incapable of earning anything" and are "a charge upon their families and upon the community."

Now, it would seem, at first, to follow, from the second of these propositions, that the "visual earning ability" was exactly synonymous with "the visual working ability," *i. e.*, that any reduction in the visual acuity, or other functional ability of the eyes, would necessarily result in a loss of the ability to follow a gainful occupation. This, however, is not at all the case, as will appear hereafter. Various ocular incapacities can, in fact, exist, without the slightest loss of earning power being occasioned thereby. However, more of this hereafter.

The Factors Which Constitute the Earning Ability.—In a normal person the complete earning ability "is a composite quantity resulting from three factors:

"(1) The unimpaired functional power of the bodily organs.

[80]Magnus and Würdemann. *Visual Economics*, p. 53.

"(2) The technical knowledge which is necessary for the carrying on of the vocation.

"(3) The ability of the individual to compete in the labor market."

The most important of these three factors is the normal functioning power (devoid of sight, a person is, as a rule, altogether dependent upon the bounty of others); a very close second in the matter of importance, at least in very many occupations, is the preparatory education, or technical knowledge; while, far in the rear, we find the ability to compete.

In making out the formula which is to express the equivalents and make up of the normal earning power, we designate that power itself by E. Then we express the three elements of which that composite quantity is made up, as follows: the functional ability, by F; the technical knowledge, by V; and the ability to compete, by K. The formula for the full normal earning ability is, then, this:

$$E = F V \sqrt[x]{K}$$

K, it is of course necessary to notice, is taken as a root, not as a full, value. The reason for this is stated by Magnus and Würdemann thus: "In this formula we put the two quantities, F and V, in their full value and accept K as a root value. There would be nothing changed in the total value of the formula itself because as the root of 1 is always 1, and we regard F, V, and K as 1, it is immaterial for the formula itself if we take one of the three quantities as a root or not, but this proposition immediately changes when the part introduced as a root grows smaller than 1, as happens in each ocular injury, because the root of each genuine fraction is always greater than the fraction itself. Thus the influence of K, after being introduced as a root value, if it has fallen off by an injury to $\frac{K}{Z}$ cannot be any more $\frac{K}{Z}$ but must be greater, for instance, $\frac{2K}{Z}$. Therefore, the damage to the total value of the formula will be smaller if we take K as a root value. By the total elimination of K the earning ability will not be diminished, but it will be by a smaller damage, according to the influence the damage of K shall exercise upon the value of the total formula. We will have to choose the exponent of the root as smaller or greater, according to its rating. The value of a root of a genuine fraction is much greater if its exponent is small. Therefore, if we wish to lower it considerably, we take a small, if we wish to affect it less, a greater exponent for K. While the ability to compete, K, is comparatively very little impaired through minor ocular in-

juries, it is very much so through the loss of one eye; we suit these conditions by choosing a greater exponent of the root in slight injuries, but a smaller exponent for serious ones. We will adopt for the slight injuries K as the 10th root and for serious ones according to the demands of the profession, the 7th root or the 5th root. * * * An exact calculation of such a changeable quantity so dependent upon the individual cannot be made. The calculation of the competing ability cannot be waived entirely, * * * but should include all factors that are relative; as we will show further on, the peculiarities of the individual case may always be considered.

"When we express the earning ability through the three factors, F, V and K, we present E, not as a sum, but as the product of these quantities, as multiplied thusly: $E = F\ V\ \sqrt[x]{K}$, in which the exponent x changes with the degree of the functional damage. E must always be regarded as a product and not as a sum, to meet all possibilities occurring in practice. If we add F, V and K, the formula would give wrong practical results, as we see in the following example: Supposing both eyes were lost in an accident, the quantity F of our formula would be 0. If we had connected F, V and K with the +, and added, even if K would have become 0, $V + \sqrt{K}$, which is the remainder of the earning ability, would have been left. This would be entirely wrong, because a laborer who has lost his functional ability, especially the sense of sight, should be regarded in an optical way as entirely unable to earn. Taking the same example and using our formula with F=0, E immediately becomes 0, because each product is always 0 if one of the factors is 0. If we would leave V out of our formula, E of course =0, and actual practice confirms this, because even the most simple hand work requires a certain amount of preparatory education. Finally, if we drop the third factor, the 10th root of K, the normal earning ability according to our formula becomes 0, which is likewise shown by practical experience, because, even though an individual is in good health and by reason of preparatory education has the skill to work, if his work is not needed, his economic value is *nil*. He may possess the power of working, as the factors F and V are present, but he only has earning ability when he can dispose of the work in the economic market. Therefore, if from our formula ($E = F\ V\ \sqrt[x]{K}$) we take away the factor $\sqrt[x]{K}$ (the ability of the individual to dispose of his work), the remainder, which is the formula for the working ability (A), would be $A = F\ V$.

"The 'working ability' is not synonymous with 'earning ability,' although some authors would have it so, for instance, Becker (5, p. 9): The words 'working ability' and 'earning ability may be re-

garded identical in meaning, because in each worker the latter depends upon the former.' Even if this be so, the two conceptions are not the same, and such a rendition obscures the conception of the earning ability, our definition of which should be clearly understood.

"The calculation of injury to the earning ability proposed by us starts from the formula for the *full earning ability:* $E = F\ V\ \sqrt[3]{K}$."

The formula may be simplified by the absolute omission of the factor V. Important as is this factor (the preparatory or technical education) it will never itself be damaged directly by any ocular injury. "Certainly the visual function may be diminished to such an extent that the realization of the technical knowledge becomes limited, but this injury to the earning ability in such a case does not rest upon a diminution of the knowledge and the capacity, but limitation of their use. We calculate the extent of such limitation, according to our method, directly by the factor F, *i. e.,* from the performance of the visual act, which is the essential factor in the full earning ability, damage to which is synonymous with damage to the total. Calculating F we have already used V. For simplicity's sake it would be better to omit V entirely. The *working formula* for the earning ability then would be: $E = F\ \sqrt[3]{K}$."

As, however, we look at this simplified equation, the thought is borne upon us that, before we can apply this formula for the estimation of visual economic damage, we shall have to consider the various elements of which F (the functionating ability of the eye) is composed—for F *is,* undoubtedly, a composite, and not a simple, quantity. F, in fact, is composed of:

1. The central acuity.
2. The visual field.
3. Light and color senses.
4. The adaptive faculty.
5. Muscular movements.
6. The cerebral processes.

Again, however, we may simplify: undoubtedly not all of these factors are necessary to be considered. The cerebral processes, for example, may be left out, because in cases of injury to the brain sufficiently severe to affect the cerebral ocular centers, the damage is by no means limited to these centers and the neurologist, instead of the oculist, is called in. The sense for light and color, furthermore, and that of adaptation, are not to be considered separately, because an injury limited to these functions is unknown. Such an injury is always an implication in, or complication of, an injury to the visual acuity or else to the visual field. When, therefore, we allow for damage to

the visual acuity or the visual field, we include the implicated injuries to the light and color sense and to the power of adaptation. Thus the six constituents of F reduce themselves, in practice, to only three. These three constituents stand to one another in the relation of factors of a product; for, in the following of an occupation, not a single one of these factors could be left out. Devoid of any single one of them, the possessor of the damaged eyes would have an earning power of practically nothing whatever. The elements, therefore, should be regarded as factors; not as the elements of a sum; in other words, as $0 \times 1 \times 1$, and not as $0 + 1 + 1$.

Perhaps the assertion that the leaving out, or rather the destruction of any of the three important elements of F, would result in what is practically complete annihilation of the earning power, should receive a modicum of consideration. Let us first regard the element of central acuity, which, for brevity, we may represent by the letter C. Now, a person who has, in both eyes, lost C—*i. e.,* is suffering from a large central scotoma—sees absolutely nothing whatever at which he directly looks. He can only see a given object by looking somewhat away from it, and, under such circumstances, an artisan is totally unable to work. Perhaps a person afflicted with a large central scotoma might be able to earn a trifle as a messenger. Practically, however, he is totally blind. If, again, a person, though retaining C, has yet been deprived of all peripheric vision—which we shall represent by P—he also could not work at any trade, "as is readily seen in cases of double-sided hemianopsia." Still further, if a working man were to suffer complete paralysis of all the extrinsic muscles of both of his eyes—in other words should lose what we shall represent by M—he, also, would be totally disabled. The only visual act which he could execute would be to "stare into vacancy," and see double. He would also have no power to estimate distances or the size of objects. Even though he should close or cover one eye, and thus prevent the disconcerting diplopia, the other eye would be immovable and therefore useless in an economic sense.

Returning to our formula, before we substitute for F its factor C and P and M, we must consider certain very significant matters which are connected with these factors. In the first place, as to the relative importance of these factors, C (the central visual acuity) is the most important of all. Whatever reduces C below the lowest limits demanded by the kind of trade, or calling, in question, of course produces for that work a total disability. P (peripheric vision) clearly comes next to C in importance, while, finally, there comes M. With regard to this factor M, furthermore, we have to consider the very important fact that the effect of a paresis or paralysis of a single, or

of several, ocular muscles, is very different indeed, according as we have to do with monocular or with binocular vision. Monocular vision is, in fact, but little affected even by the complete paralysis of a single extrinsic muscle. Such an affection merely diminishes the motility of the eyeball. In binocular vision, however, the element of diplopia enters in—a fact "of the greatest importance, as it excludes, temporarily, at least, retention of working binocular vision." In the construction of a formula, therefore, we treat the factor M in a different manner, according as we have in view binocular, or monocular, vision. "In the formula for binocular vision we take the muscular movements of each eye as the product of different factors, each of which corresponds to the activity of a particular muscle. Now, if we mark the muscles of one eye with ($m^1m^2m^3m^4m^5m^6$) and those of the other ($m'^1m'^2m'^3m'^4m'^5m'^6$) etc., we would represent the whole muscular activity as ($m_1m_2m_3m_4m_5m_6$) ($m'_1m'_2m'_3m'_4m'_5m'_6$). In this conception the whole product would be 0, by losing one single muscular motion, and therefore the binocular act would be negative. In monocular vision the muscular activity should be conceived as the sum of the single performances, because by losing one of them only an ocular detriment has been created and not total earning disability, thus $m_1+m_2+m_3+m_4+m_5+m_6$."

Still further, M and P should both be added to the formula as root, not full, values, precisely as was done in the case of K (afterwards omitted) and for exactly the same reason—*i. e.*, the damage to the total value of the formula will be smaller (which accords with the less importance of M and P as compared with C).

In the words of Magnus and Würdemann again: "* * * the value of the root of a proper fraction increases with the amount of its exponent, thus, if we introduce M with a greater exponent of the root than P, in the case of damage to M, it will exercise less influence upon the total value of the formula. We believe that we may place the relative value of the visual field and the muscular movements by choosing as exponent of the root in the former 2, and in the latter 4. Of course, these are arbitrarily chosen, as it is an undisputed fact that the central visual acuity, peripheric vision and the muscular movements have different meanings in the act of vision, the proportional valuation of which cannot be put into figures from observation nor from measurement, it is certainly allowable for the mathematician or the physician to estimate the amounts of these exponents differently, but the formula itself will not be changed."

The formula, then, for binocular vision is as follows:

$$S^2 = C\sqrt{P}\sqrt[4]{(m_1\,m_2\,m_3\,m_4\,m_5\,m_6)(m'_1\,m'_2\,m'_3\,m'_4\,m'_5\,m'_6)}$$

In this formula, C is the central visual acuity in the better eye.

The formula for monocular vision, however, is this:

$$S_1 = C\sqrt{5/6\,P}\sqrt[4]{2/3\,(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}.$$

the fraction 5/6, standing before P, denotes the fact that the monocular field of vision is 5/6 as extensive as the binocular. The value of the muscular function is 1/3 less in monocular than in binocular vision; hence it is estimated at 2/3 the binocular value.

Economic Limitations of C.—The economic limitations of the central visual acuity are not identical with the scientific limitations of the same faculty. This, at first, may sound a trifle startling, yet, on due consideration, we find that the statement is true. Take for instance the downward limitation. Science calls a person blind only when the acuity has entirely disappeared. Economically, however, an individual is blind when the acuity has become so low that the earning power is *nil.* Take, again, the upward limitation. Scientifically, the acuity equals a hundred per cent only in case the acuity is approximately 20/20. Economically, however, the acuity may equal a hundred per cent. *(i. e.,* permit of plenary earning capacity) although it is only 20/30, 20/40, or even 20/50 or less. Much depends upon the nature of the occupation, of course, some occupations requiring a high, others only a low, degree of central visual acuity in order to the possession of plenary earning power. However, there is hardly any occupation which demands for its full and adequate exercise the possession of scientifically perfect visual acuity. Generally speaking, we may say that an acuity of 1/20 is the extreme downward limit of useful acuity in any occupation, and 20/30 the extreme upward requirement. Further, the maximum and minimum limits do not have to exist in both eyes. If one eye possesses a minimum, the other may possess less (even, in fact, as little as absolute zero) and still the acuity of the eyes as a visual whole is up to the minimum requirement. Likewise, if one of the eyes possesses a maximum acuity, the other may possess less (even, in fact, as little as absolute zero) and still the acuity of the eyes as a visual whole is up to the maximum requirement. Magnus and Würdemann divide the different occupations into two groups—those requiring high, and those requiring low, degrees of visual acuity, and specify a rather large number of trades and professions belonging in each group. To each of the groups they assign a maximum and a minimum C. Much as we deplore the inability, we cannot reproduce such matters in this chapter, on account of lack of space.

The Economic Limitations of P.—As in the case of C, so also in the case of P, the scientific and the economic standards are not at all the

same. In the vast majority of callings, monocular limitations of the field do not impair the earning power. Magnus and Würdemann, following Schroeter, divide the binocular field into three zones of 30° each. The first zone reaches from the outermost periphery to 60°; the second, from 60 to 30°, the third from 30° to the fixation-point. These three zones are not of equal value in certain respects, yet, as what zone 3, for instance, lacks in functional ability, it makes up for by its greater exent, these three zones of P are accorded equal value. By this conception, then, the entire binocular field of vision (exclusive, of course, of what we have represented heretofore by C) consists of three factors of equal value. Thus a loss of one eye entails a loss of 1/6 the binocular field (no more than that, because of the overlapping of the single fields in the binocular) and a homonymous hemianopsia entails a loss of 3/6=½.

Economic Limitations of M.—The economic loss (in a person possessed of binocular vision) arising from the impairment of a single ocular muscle is very great indeed, because, diplopia appearing in consequence of the injury, one eye must necessarily be excluded from the visual act, in order that useful vision may be exercised at all. The loss, therefore, economically, is exactly the same as that which results from the destruction of one eye. In case, however, the subject was possessed before the accident of monocular vision only, then a smaller degree of economic loss should be imputed to the impairment of a muscle in the seeing eye. In fact, in such a case, the economic loss is approximately 1/6. However, the six extrinsic muscles do not all possess exactly the same value, at least under any and all circumstances. Thus, for a miner or a compositor, the rectus superior is especially important; for a sailor, the rectus externus; for a bookkeeper, a jeweler, an oculist, etc., the rectus internus. For people generally, the rectus internus possesses the most value.[81]

Special Consideration of the Ability to Compete (K).—When a person's eyes are injured, the damage which has been done to him is frequently twofold: first, there is the actual impairment of the working ability of the eyes; second, there is a diminution in the injured person's chances of getting or of keeping a job. "Practical experience," for example, "shows that a one-eyed person not only has more difficulty in finding employment,[82] but that in some factories his visual disorder

[81]It is only now and then that injuries of the ciliary muscle affect the earning power. By the use of convex lenses, the impairment can, in the vast majority of occupations, be compensated. On this head see *Encyclopédie Française d'ophtalmologie*, Paris, 1910, Vol. IX, p. 713.

[82]We may remind ourselves in this connection that the inability to estimate distances and the size of objects, which occurs at once after the loss of an eye, endures but a very short time—certainly in adults not more than six or eight months and in children two or three weeks.

makes it difficult for him to retain his employment * * *. The injured person, therefore, has a right to claim not alone a compensation for the impairment of his capacity for work but also the difficulty which he encounters in making the most of this capacity." Now, this ability to compete (K) is composed of two elements: 1, the applicant's visual powers; 2, the judgment which the prospective employer will probably form concerning these powers. As to the first of these elements, we express it, in the formula for K, under normal circumstances, exactly as we expressed the normal act of vision (*i. e.,* $C\sqrt{P}\sqrt[4]{M}$), "but in the case of accidents the impaired value of the act of vision should be put in as the lowest value in the root. * * * we have given the reasons for accepting the ability to compete as the lowest value and we have likewise shown that the ability to compete is of less value in the formula for the earning ability E than the other factors, *i. e.,* it has a smaller influence upon the value of E than the others. We have, therefore, adopted the ability to compete, K, as a root value. For, if K be reduced by an impairing of the act of vision, it becomes a proper fraction, for instance, $\frac{K}{Z}$. Now the root of a proper fraction is always greater than the fraction itself; the value of K after the impairment if it is taken as a root value cannot any more be $\frac{K}{Z}$, but it must be greater, for instance, $\frac{2K}{Z}$. By taking K as a root, its value, in the case of a visual impairment, is greater than it would have been if K without root would have been taken into the calculation. And as the amount of the earning ability is directly fixed by the amount of the ability to compete, K exercises less influence upon the earning ability than the other factors, as soon as we insert K as root in the formula for the earning ability. The full formula being:

$$\sqrt[x]{K} = \sqrt[x]{S_2\sqrt{P}\sqrt[4]{m}}."$$

As to the second of the elements which go to make up K, *i. e.,* the part depending on the judgment of the employer, that part is expressed by the exponent of the root which is chosen for K. "If we think that the esthetic differences between simple blindness of the scientific standard without injury to the looks of the eye and the loss of the eyeball, or, for instance, the formation of a bad-looking eye, as leucoma or staphyloma are greater, we may give expression to our opinion by choosing a great root exponent for the ability to compete in the case of simple blindness without deformity. By leaving the selection of the root exponent to the judgment of the calculator, sufficient room is

given to the individual conception of each case; *thus our formula adapts itself to the peculiarities of the individual case and to the judgment of the physician, avoiding thereby a rigid form and doing justice to both parties.*" In view of the fact that we are often "in the peculiar position of estimating an ocular impairment of the ability to compete when there is no real defect of working vision," (for instance, in the case of a man with a bad-looking leucomatous eye, whose acuity is, say .25, while the fellow eye is absolutely normal) "we express the diminution of the ability to compete in all cases by the arithmetical proportion of the visual acuity of both eyes." In the case of the leucomatous individual just supposed, the numerical expression for the ability to compete would be:

$$\sqrt[10]{\frac{1+0.25}{2}\sqrt{P}\sqrt[4]{(m_1\,m_2\,m_3\,m_4\,m_5\,m_6)(m'_1\,m'_2\,m'_3\,m'_4\,m'_5\,m'_6)}}"$$

Because of lack of space, we cannot here enter into the numerous and ingenious applications of this formula which are furnished by Magnus and Würdemann, though these are extremely interesting and instructive. We can only say, in bidding farewell to the formula in question, that though such an extremely elaborate hieroglyphic is by no means presentable to a jury, or, indeed, to corporation management, except in isolated instances, yet that the ophthalmo-surgical expert who has mastered the subject of "visual economics" and particularly the comprehensively scientific formula which we have been discussing, namely:

$$E = C\,(\max.)\,\sqrt{P}\,\sqrt[4]{M}\,\sqrt[x]{\frac{C_1+C_2}{2}\sqrt{P}\,\sqrt[4]{M}}.$$

will find himself indubitably better able to wrestle with the question as to what degree of economic loss has been sustained by a given person in consequence of some particular injury.

Questions of a General Nature Relating to the Power of Vision.

Questions under this head are chiefly these: (1) As to the possibility of recognizing persons[83] and objects under various sorts of cir-

[83]In this connection, the following, extracted from *The Law and The Doctor*, Vol. II, p. 39, may prove interesting: "* * * the physician, testifying as to the possibility or impossibility of a certain act or thing, should remember that his evidence may be rebutted by testimony of a witness that he has performed the act or accomplished the thing which the expert has testified to be impossible. A case illustrating the pertinence of this suggestion was related to the author some years ago by a lawyer who was present at the trial. Two men had broken into the house of an old couple at night and entered the sleeping-room. The old people were awakened by the noise. The old lady, rising up, took her glasses from the head-board of the bed, and, by their aid, claimed to have recognized the men just as they shot and killed the husband. Upon trial of

cumstances by ordinary daylight; (2) by a gleam of lightning; (3) by the flash of a pistol; (4) by moonlight; (5) by starlight.

1. By ordinary daylight. The perception and also the recognition of persons and things by means of the sense of sight depends on the size of the object, its brilliancy, its distance from the observer, the clarity of the atmosphere, the observer's familiarity with the person or object to be perceived, his position with respect to the sun *(i. e.,* whether gazing squarely or partly toward, or directly away from the sun) the intensity of the illumination which is shed upon the object, and, finally, the acuity of vision on the part of the observer. The ordinary test for the acuity of vision is this: The subject is placed at a distance, generally, of 20 feet (6 metres) from a card, chart, or board, on which are printed lines of isolated letters *(i. e.,* letters unrelated in sense) of varying sizes, all the letters of a given size being printed, as a rule, in one and the same line, and a certain proportionate relationship subsisting between each letter and every other letter on the card. This proportionate relationship is based, according at least to the method most generally employed, upon the principle that the minimum visual angle is precisely one minute. Each letter, in whatever line, is constructed of blocks, or units, each of which subtends, at the distance indicated by the number of the line in which the letter occurs, an angle of exactly one minute. A whole letter subtends, laterally as well as vertically, an angle of 5′, being composed laterally and vertically, of five of the constituent blocks, or units. Now, the line numbered 20 should, as already hinted, be read by the average normal, unassisted eye at a distance of 20 feet—*i. e.,* the distance at which the test is ordinarily conducted. The line numbered 15, is supposed to be read by the same kind of eye at 15 feet; that numbered 10, at 10 feet. The line that bears the number 30 should be read at 30 feet, and so on from line to line of larger and larger type till the line numbered 200 (which is generally the largest used) is reached—a line which should, of course, be read throughout by the average normal, unassisted eye at 200 feet. If the subject reads at a distance of 20 feet the line numbered 20, we express the vision of that eye thus: Vision (or simply V) = 20/20

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the accused, the defense introduced an oculist who testified that he had examined the eyes of the old lady and the glasses in question, and that it was a physical impossibility for her to recognize a person by the aid of those glasses at the distance at which it was testified the murderers were, as the lenses of the eyes and the glasses could not focus at that point. Counsel for the prosecution, in rebuttal, identified the glasses in question, asked the old lady to take the witness stand, and caused several men, including the accused, to stand in front of her at the distance testified; thereupon he handed her the glasses and asked her to 'pick out the men who shot your husband.' After adjusting the glasses, she peered into the faces of the several men until she came to the accused, when she promptly identified them as the men who had committed the crime."

(20/20, of course = unity, or normal). If the subject can read with the given eye at 20 feet nothing smaller than the line numbered 30, his vision = 20/30, or 2/3 the normal. If the line numbered 15, then 20/15, or 33⅓ per cent. better than even the average, normal, unassisted eye—a power of vision which is now and then found. Thus, the distance at which the subject reads is always the numerator of the fraction which expresses his visual power, and the number of the line that is read is the denominator. If the sight is normal this fraction = unity (20/20); if less than normal, the fraction is a proper fraction, and, if more than normal, an improper one. The vision of the two eyes together, assuming that the sight of each is fairly good, and that it is much the same in each, as in the other eye, is often a little better (a fraction of a line, in fact) than that of the better eye alone.

Inability to read Snellen's line numbered 20 at a distance of 20 feet *(i. e.,* subnormal acuity) may arise from errors of refraction (which, in almost every instance, are correctable by glasses) by obstruction to the passage of the light through the eye to retina and optic nerve (as by any opacity in the cornea, the aqueous humor, the lens—cataract—or the vitreous body) by pathological conditions of the retina or optic nerve, the optic chiasm, the optic tract, or, finally, the cerebral portion of the visual apparatus.

Assuming, now, that the eye has normal acuity of vision (naturally, or after correction by means of lenses in case subnormal acuity is due to an error of refraction) how far can such an eye (an eye, that is, with 20/20 acuity) perceive a man of ordinary height, out of doors, by ordinary solar illumination? According to various experiments, such an eye perceives an ordinary man, in ordinary attire, over level ground, (assuming the observer himself to be a man of ordinary height, and with the sun not in his eyes) at a distance of 3½ miles. Brilliant attire, exceptional clarity of atmosphere, very abundant sunshine, and unusual stature in either the observer or the observed, may, combined, increase the distance by as much as perhaps a quarter of a mile. On the other hand, dense fog, diminished illumination, rough ground, and diminutive stature in either the observer or the observed, reduce the distance greatly; in fact, a fog alone may reduce it to a very few feet.

Different, indeed, is the power to recognize from the ability merely to discern. Here, also, two new elements come in: First, presence or absence of personal peculiarities in the observed; second, the knowledge or the lack of knowledge concerning these, on the part of the observer. Persons with marked peculiarities can be recognized, in broad daylight, by those who know them well, at 110 yards (100 metres). A person of marked peculiarities can be recognized by one who knows him only slightly, at 70 to 80 yards. A person devoid of peculiarities can be rec-

ognized by a person well acquainted with him, at about 70 or 80 yards. Finally, a person devoid of marked peculiarities can be identified by those who are only slightly acquainted with them, only at the rather surprisingly short distance of 25 to 35 yards.

As to the smallest objects visible to the unassisted eye, it may be observed that lines (not, of course, in the geometrical sense) are more perceivable than are squares, circles, triangles and the like, presenting the same identical extent of surface to the eye. The smallest black square on a white ground, or white square on a black ground, that can be seen by the normal human eye, under ordinary (indoor and indirect) solar illumination, is about the 1/500 of an inch. Brilliant particles, such as grains of gold-dust, can be perceived by the eye even when presenting so little area as 1/1,125 of an inch. "Lines," as stated, are more perceptible than figures more compact. Thus, opaque threads, held between the naked eye and a window, can, by ordinary, indirect solar illumination, be discerned though only 1/4,000 inch in diameter.

2. By lightning. The question has arisen, especially in criminal trials, as to the possibility of recognizing a person when the only illumination consists of a gleam of lightning. It arose, for example, in the threadbare, if also classic, instance of the lady who, returning home from India, declared that she saw distinctly, and could afterward identify, a man who was "robbing her trunk in the cabin of a vessel, on a dark night." Tidy[84] declares "that a flash of lightning is in *many cases,* but by no means in all, amply sufficient for purposes of identification." Further, that he "was able on one occasion to detect a black hair-pin on the ground by a flash of lightning, and to pick it up when the next flash came."

3. By the flash of firearms. The possibility of recognition by means of the flash of a firearm has also formed the ground of questions asked at a number of criminal trials. On this head there is little satisfactory information, thus far, to be obtained. Cauvet, however, cited by Allen McLane Hamilton,[85] sets forth the following conclusions as having been drawn from experiments conducted by him: "(1) That the person firing a pistol may be recognized if the observer is placed very near him—say five paces—and at the side of the line of fire; (2) that he may be recognized when the discharge has been in a close place of small dimensions, and the observer is in a stooping posture or squatting; (3) that the chance of distinguishing the person firing is affected by the quality of the powder employed, the best English powder en-

[84]Tidy. *Legal Medicine*, New York, 1882, Vol. I, p. 213.

[85]Hamilton (ed.) *A System of Legal Medicine*, New York, 1900, Vol. I, p. 191. (Hamilton gives no further citation than merely the name of Cauvet.)

abling the observer, when near or by the side of the person firing, both to see and identify him."

4. By moonlight. A person with marked peculiarities, illuminated by the best of moonlight, can be identified by an intimate acquaintance no farther than 16 to 18 yards.

5. By starlight. Under the clearest starlight, however, no farther than 3 to 4 yards.

Flashes of light ("stars" or "sparks") from blows on the head cause no illumination of external objects; they are "subjective" merely. No recognition of persons or things in the external world is, therefore, possible by means of them. The matter would hardly seem to be worth mentioning, but the question has been actually asked of expert witnesses.

The Condition of the Eye After Death.

The special significance of the ocular signs of death arises from the fact that, in lego-medical investigations, it is now and then desirable to determine as nearly as possible the fact of death and, occasionally, the very time of death.[86] In ordinary circumstances, the presence of death is easy enough to make out. Even if a corpse is covered with a sheet, there is something in the posture, or else in the motionless rigidity of the limbs, that tells us almost unmistakably that death is below. Sometimes, however, the diagnosis of death is difficult; then it is that we need the assistance of art.

The signs of death relate to three stages: 1, The stage of transition; 2, the cadaveric stage; 3, the stage of putrefactive processes. These terms do not seem to require elucidation.

The signs in the stage of transition (to some extent also in the cadaveric state) have reference to four sets of organs: 1, The circulatory system; 2, the respiratory system; 3, the voluntary muscular system; 4, the eyes.

Only the signs relating to the eyes, of course, concern us here, and further, even these chiefly in the stage of transition.

1. The adnexa. The skin of the lids is pale, of course, as death approaches, or actually sets in, excepting in certain diseases, but this palpebral pallor is of very little value as a sign of death. What about the open or closed condition of the lids? Much discussion has been wasted on this question. The matter as a whole, however, may be summed up thus: In cases of "natural" death *(i. e.,* gradual dissolu-

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[86]As a single instance of the necessity which now and then arises for establishing with the utmost accuracy the very moment when death takes place, we may mention the case where the descent of property down one line or another, depends upon the answer to the question of whether A died first or B.

tion as a result of disease) the lids are as a rule, just about half open, both during the stage of transition and also in the cadaveric state. Hence, in fact, the well-known necessity of "closing the eyes of the dead." In cases of drowning, on the other hand, the lids are apt to be puffed (edematous) and more or less tightly closed, while, after sudden death from gun-shot wounds, the lids stand widely apart. To all these rules, however, there are numerous exceptions.

A deep groove, in the cadaveric state, appears between the upper lids and the eyebrows, but this appearance, too, is not to be regarded as a positive sign of death; for it sometimes shows itself when death has clearly not occurred, and, on the other hand, is often absent even when the body as a whole has well advanced into the stage of putrefaction.

2. The globes. The eyeballs, always in the cadaveric state and almost always in the stage of transition, retract, and this sudden or gradual drawing backward of the eyeballs into their sockets, imparts to the death agony one of its most nearly characteristic features. Nevertheless, as a certain sign of death, the retraction of the globes is not at all to be trusted. The phenomenon, in fact, occurs in people who, though very sick, recover, and, on the other hand, in a certain proportion that die, the appearance is either not to be noticed at all, or else is very slight. In the stage of transition the retraction is due to spasm of the extrinsic muscles; in the cadaveric state, to *rigor mortis* of the same parts. When deferred till the cadaveric state it is one of the earliest symptoms of that condition, for *rigor mortis* almost invariably sets in first either in the heart muscle or in the extrinsic muscles of the eye.

The direction which is given to the globes by the passage from life into death is such that the optic axes are rendered parallel or even a little divergent. This is the "staring into vacancy" of the novelists. This sign, too, is not reliable as an indication of dissolution, because it often occurs in serious illness without death, while, on the other hand, an actual convergence of the visual axes has been observed, though rarely, after undoubted dissolution.

3. The conjunctiva and cornea. These structures become insensible very early in the stage of transition, but, because the same thing happens so often in serious diseases, the sign is absolutely worthless. The cornea, it is barely worth mentioning, retains its sensibility longer than does the conjunctiva.

The thin gelatinous film which forms upon the cornea as a person dies, is one of the more impressive phenomena of dissolution, furnishing indeed, as it does, the most important element of "the finely ruined eyes of death." When this film is seen to form, a person is almost sure-

ly dying. And yet, after all, not quite surely, for, as a fact, the same identical phenomenon has been witnessed in the living—for instance, in the course of serious cases of typhoid, of meningitis, and various cerebral affections—who afterwards recovered. However, in the living, it is almost always accompanied by the tell-tale symptoms of active inflammation, whereas, in the dying and the dead, the exsanguinated vessels of the sclera and conjunctiva give an opposite account.

The film in question is very delicate and fragile, and easily wiped away. It seems to consist of lymph and other fluids, which exude through the ocular tissues.

Wrinkling of the cornea has also been set up as a characteristic sign of death. It seems to be dependent on the same transudation of intraocular flüids that results in the formation of the corneal film. As a result of this transudation, the intraocular tension diminishes, and so the cornea wrinkles. The wrinkling seldom becomes detectable till the corneal film has pretty plainly formed, hence the sign in question is a characteristic of the cadaveric state rather than the stage of transition. Its value as a sign of death is therefore subordinate.

4. The sclera. The lethal discoloration of the sclera has been alleged (like all the other ocular manifestations of dissolution) to be an absolutely certain sign of death. This sign, however, considered alone, is worth but little more than any of the other signs, perhaps not quite so much as some of them. It possesses the advantage (which is also in some respects a disadvantage) of appearing very early. In fact, in cholera patients it appears as early as eight hours prior to death. It consists of a blackish discoloration, which first appears in the outer scleral triangle, *i. e.*, the space which lies between the outer margin of the cornea and the two lid margins as far as the outer canthus. Next it appears in the inner scleral triangle. Finally, it forms in the portion of the sclera that is covered by the upper, and then in that which is covered by the lower lid. It appears more rapidly and more certainly in a warm than in a cold room, and is very often seen in those who die of phthisis pulmonalis and typhoid fever. It is said to consist partly of subconjunctival ecchymosis and partly of choroidal pigment. Its nature, in fact, has never been exactly determined.

5. The iris. When a person dies, does his pupil contract or dilate? The question would seem to be a simple one, and one very easy to answer. Nevertheless, a great deal of bitter controversy has been waged about this easy-seeming inquiry. We cannot here afford to revive a discussion which has never appeared to be profitable, and which, besides, has given excellent proofs of its own dissolution. However, it seems to be pretty well settled that, at the very moment of death, the pupil, in the vast majority of cases, dilates. This dilatation, however,

continues for a few hours only; with the setting in of *rigor mortis,* the pupil contracts. For one hour after death the pupil responds to eserin and atropin; but not for any longer time. It responds to galvanism, in many cases, for as long as five hours.

6. The fundus. If, at the time of death, or a little while thereafter, the gelatinous film upon the cornea be removed by first moistening it and then wiping it away, the ophthalmoscope can be employed to some advantage. By means of this instrument it has been determined that, at the moment of death, sudden and very striking alterations take place in various portions of the fundus. The papilla becomes anemic, as it were in a flash, and the reddish color of the remainder of the field turns from the normal red or pink almost as suddenly to a sickly yellow. The arteries disappear entirely, and the veins become much smaller, and rather irregular and broken. In all this, however, there is nothing absolutely declaratory of death; similar conditions have been observed in syncope and lethargy.

Is there, then, no ocular symptom at all that will serve as an indisputable sign of death? There is absolutely none. However, when taken as a whole, the ocular signs of death are well-nigh incontestable, especially when supported by tests of general character, such, for instance, as failure of the heart and lungs to respond to stethoscopic examination, and failure of a finger to become cyanotic after a ligature has been tightly placed around it. Still more certain, of course, are such signs as general *rigor mortis,* cooling, and suggillation (postmortem lividity) while, as an absolutely undeniable indication of death, comes putrefaction.[87]

Post-Mortem Optograms.—Among the laity there obtains a belief that the retinas of those who have perished by assassination retain for some time a photographic image of such persons as last appeared before the eyes of these murdered people. In this idea there is only the merest shadow of an atom of truth. Vernois (in 1870) having made some photographs of a murdered person's retina, thought that his pictures exhibited the figures of a man and a dog in the very attitude and posture of attack. These photographs he displayed with some pride to the Society of Legal Medicine in France, and, in fact, to many other physicians in other places; but, unfortunately, he never quite succeeded in getting any other medical person to believe that the pictures represented a man and a dog. In fact the pictures, if such they were, were altogether too vague and indefinite to be of any practical service in the detection of evil-doers.

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[87]Perhaps it may be as well to remind ourselves that the earliest sign of decay is a spot of green on the belly, generally in the neighborhood of the umbilicus. Of the internal organs, the liver is, as a rule, the first to decay, the uterus the last.

Kühne, of Heidelberg, later placed gratings in front of rabbits, then killed the rabbits very suddenly and, without any delay whatever, proceeded to make a photograph of the retinas of these animals. Very distinct pictures of the gratings were in some cases secured. However, the killing of the animals had to be practically instantaneous, and the making of the photographs well-nigh as rapid. A man who, by methods such as these, could make successful pictures of murdered people's retinas would have to be upon the scene in ample time to catch the murderer by a very much simpler plan.

The Ocular Signs of Sleep.

Sleep is sometimes simulated, but the fraud is easily found out. The eyeballs in genuine sleep, for one thing, are nearly always absolutely motionless, whereas, when the sleep is only feigned, the globes are seen to move about a little beneath the closed lids. If an upper lid be lifted, the fact will be observed, in genuine sleep, that the pupils are very small, while, as the subject wakens, the pupils dilate extremely wide, even in the presence of strong light.

Ocular Indications of Poisoning, Burning, Etc.

The effects of the commoner poisons on the eye may be very briefly stated as follows:

Alcohol.—Conjunctival injection and swelling, both in acute and in chronic poisoning. In chronic poisoning, there is present, in addition, a paresis of the *orbicularis palpebrarum,* combined with anesthesia of the cornea, so that involuntary winking is almost entirely abolished; hence, "the fixed, unwinking stare" of the hard drinker, when sober as well as when drunk.

Arsenate of Copper.—This chemical is employed in the manufacture of artificial flowers and confectionery and in fancy baking. The ocular symptoms produced by this substance in those who work therewith habitually, are conjunctivitis and swelling of the lids.

Belladonna and Atropin.—Swelling of the lids, excessive lustre of the corneæ, mydriasis, and paralysis of the accommodation. Exophthalmia has been observed, as a result, no doubt, of paresis or paralysis of the recti, together with a similar condition of the orbicularis, permitting the lids to be widely separated by the forward-pushing globe.

Chloral Hydrate.—The prolonged employment of this drug produces conjunctivitis and severe itching of the lids, inside and out.

Chloroform and Ether.—During the stage of excitement, pupillary dilatation. Thereafter, progressive pupillary contraction. In the "surgical state" the pupils are immobile, as well as contracted.

Curare.—Exophthalmia, conjunctivitis, and excessive lachrymation.

Digitalis.—Exophthalmia, together with fixity of the visual axes and conjunctival injection.

Illuminating Gas. —Diminution of visual acuity, with contraction of the visual field; dilatation of the retinal veins and contraction of the arteries. Persistent bilateral hemianopsia after recovery, has been recorded. There is sometimes paralysis of the various ocular muscles, extrinsic and intrinsic, accompanied or unaccompanied by exophthalmia. When the recti are paralysed, there is always exophthalmia.

Naphthol-B.—When used for a considerable length of time, even externally, this drug not infrequently produces cataract and various alterations in the choroid and retina.

Nicotin.—Exophthalmia and corneal brilliancy.

Opium and its Alkaloids.—Myosis and spasm of the accommodation, together with dimness of the cornea—producing the so-called "fishy" look.

Prussic Acid.—Exophthalmia and diplopia. After death, the eyes are fixed, prominent and wide open, and are possessed, furthermore, of a singularly life-like expression.

Quinine.—This drug sometimes, in excessive doses, produces a peculiar fundus condition known as "quinine amaurosis." There is extreme contraction of the retinal arteries, and the papilla is very white. Recovery not infrequently occurs, but there is often a permanent peripheral contraction of the visual field.

Strychnin.—Prominence of the eyes and fixity of the visual axes, especially during the convulsions.

Thyroid Gland.—Optic neuritis, followed by optic atrophy.

Burning.—After extraocular burns, the following ocular symptoms have been noted: retinitis, chorio-retinitis, retinal hemorrhages, neuritis and optic atrophy.

Hanging.—Puffing and blueness of the eyelids, exophthalmia, and conjunctival injection. Punctate ecchymoses of the conjunctiva have been observed, but not at all so frequently as after strangulation and suffocation.

Strangulation and Suffocation.—Before death: The eyes are livid and prominent and there are often hemorrhages from the conjunctivæ. Subjectively, the vision is lost soon after the beginning of the process. After death: Exophthalmos, redness of the conjunctivæ, and minute conjunctival ecchymoses. The punctulation of the conjunctiva is said to be well-nigh characteristic.

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[88] "Nearly one-half of the accidental poisonings in New York City in 1888-92 were by illuminating gas, and the same agent was used by suicides more frequently than any other except paris green and 'rat poison.'"—R. A. Witthaus in Witthaus and Becker's "*Medical Jurisprudence, Forensic Medicine, and Toxicology*," New York, 1896, Vol. IV, p. 848.

The Ocular Signs of Identity.

Rather often, sometimes even in the dead, the eyes and their adnexa afford most valuable indications of identity. These indications may be classified as (1) anatomical, (2) pathological, (3) professional.

1. *The Anatomical Signs.*—These relate to the brows and lashes, the lids, the irides, and the sclerotics.

The *brows* are seldom characteristic of the individual, but they often afford some slight indications of identity. Thus, as to the matter of color and texture, it is well known that the structures in question vary from blond to black and from silky-fine to exceedingly harsh and coarse. Years do not so often or so early alter the color of the brows as they do the hair of the head. As to form, in some individuals the brows are straight, in others arched; when arched, they take, in some, a downward inclination at the outer ends, in others, an upward. In some persons they unite at the root of the nose to form one single band.

Changes in the color of the hair often occur naturally. Children's hair gets darker with increasing age, while the hair of adults gets lighter.

The eyebrows and lashes, as well as the head-hair, are now and then colored artificially by those who desire to conceal their identity. Oftenest employed for the purpose are the salts of lead, silver, and bismuth, in solution. The changes in color are due to the combination of these metals with the natural sulphur in the hair, forming the dark metallic sulphides. Lampblack, rubbed up with some fatty substance, is now and then used as a hair-dye.

The fact of artificial coloration of the hair is, as a rule, very easily detected. If lampblack has been used, washing the hair with ether will readily expose both the fraud and the natural color of the hair, since, when the ether dissolves the fatty substance which acts as a menstruum for the dye, the dye is no longer adherent to the hair, but comes away in the ether, leaving the hair in much its natural condition.

To detect the presence of a metallic dye, wash the hair in slightly acidulated water; then test the water chemically for the presence of the metals above-mentioned—lead, silver, and bismuth.

The microscope is often useful for the detection of artificial coloration of the hair. If fatty pigments have been used, the microscope reveals the presence of the fatty particles plainly. Sometimes, too, this instrument shows places on the individual hair which the dye has failed to affect.

The *lashes* are naturally pigmented either exactly like the brows and the head-hair, or just a little lighter. They are dyed artificially in

the same way as the brows and the head-hair, and the fraud is, of course, detected in precisely the same manner.

The *lids* afford a variety of signs. Thus, age is often indicated, approximately, by the wrinkling of the lids, especially at the outer canthi ("crow's feet") and by the puffing of the lower lid especially ("money-bags"). The skin of the lids also thickens with age, and becomes in color brownish or yellowish.

The *iris* is in infants nearly always of a light blue. In later childhood, however, it assumes the particular color which it is to retain throughout the whole of life, excepting in senility, when the color again becomes perhaps a trifle lighter.

Congenital anomalies of the irides, the chief of which are colobomata, heterophthalmos (difference in hue of the irides in the same person) have been considered in a former portion of this chapter. Suffice it here to remind ourselves that such distinguishing peculiarities are possessed of the utmost value as a means of establishing identity.

The *sclera* is in some persons yellow, in others bluish-white, in still others clear white. These differences are often racial; thus, the Jews are noted for the perfect albugineity of their scleræ. Some persons possess, congenitally, spots of pigment in their scleræ, and these, of course, possess much value as a means of identification.

2. *The Pathological Signs.*—It would be improper to attempt to mention all the pathological conditions in the various ocular structures which, on occasion, could become of greater or less service in the establishment of identity. The chief pathologic signs, however, are the following: Scars of all sorts in the skin of the lids and brows;[89] sebaceous cysts; slit canaliculi; cicatricial conjunctivæ, resulting from trachoma; pinguecula; pterygium; cataract; the characteristic scars produced by the various bulbar operations; and, finally, the numerous pathological appearances of the fundus.

We ought to add that lashes and brows—as well as the hair of the head—have turned white from fear in a single night, and, further, that hair is often much darker on its return after loss during typhoid fever and other infectious diseases.

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[89]Including, of course, the tattoos produced by explosions of fire-damp and of gun-powder. On the methods whereby these important kinds of tattoos may be distinguished, see that division of this chapter, entitled "*The Commoner Injuries with which the Ophthalmo-Surgical Expert has to Deal.*"

The tattooing produced by explosions of fire-damp occurs not only in the skin of the lids, but also on the conjunctiva of the palpebral, as well as the bulbar portion. Thus, I have, at the time of writing this paragraph, under treatment, a coal-miner, on the inner surface of whose right lower eyelid are plainly visible several characteristic marks (ancient) produced by fire-damp explosions. There is not a single spot of the sort in any other part of the eye, or of the fellow eye, or even on the face or head. It would be quite possible to assert, with a high degree of certainty, merely on the strength of these tiny marks, that the subject was a coal-miner.

3. *Professional Signs.*—The chief of these relate to the various sorts of dust produced in the work of different occupations, and which cling to lashes and brows, sometimes in spite of repeated washings. Thus, for instance, coal-miners, chimney-sweeps, firemen, engineers, and coal-heavers exhibit a dusting and staining of the brows and lashes by coal or soot; locksmiths show on the same parts a dust composed of copper filings; millers and bakers carry flour in the same situation, while marble-cutters and stone-breakers exhibit, as is well known, on brows and lashes, a plentiful quantity of siliceous dust. There are many other occupations which leave a characteristic powder on the hairs about the eye, even the names of which it is not necessary to mention. We should not forget, however, in this connection, the tanned and thickened skin and the yellowed and thickened conjunctivæ of outdoor workers, as well as the special liability of such persons to pinguecula and pterygium.

III.

OPHTHALMO-SANITARY LEGISLATION.

Ophthalmo-Sanitary Laws in the United States.

The laws enacted for the prevention of injuries to, and diseases of the eye, are, in any country, "few and far between." Nevertheless, such laws exist, and are most conveniently divisible, as regards America at least, into these two main classes:

1. Laws devoted solely to the prevention of injuries to, and diseases of, the eyes.

2. Laws which, though embracing other matters, nevertheless contribute partly or indirectly toward the prevention of such injuries and diseases.

(1.) Among the most important of the first named enactments are those relating to the prevention of blindness from ophthalmia neonatorum. Many of the states of the Union have now adopted such a law, and perhaps the Michigan statute[90] may be copied herein as being fairly representative: "* * * should one or both eyes of an infant become inflamed or swollen, or reddened, or should any pus or secretion form in the eyes or upon the edges of the lids, at any time within two weeks after birth, it shall be the duty of any midwife, nurse or other person having charge of such infant, to report in writing within six hours after discovery of such inflammation, redness or formation of pus, or secretion, to the local health officer or some legally qualified practitioner of medicine in the city, town or district in which such case shall

[90]*Compiled Laws of Michigan*, 1897, Vol. II, p. 1419, sec. 4475.

occur, the fact that such inflammation, swelling or redness or accumulation in the eyes exists."

The penalty is a fine not exceeding one hundred dollars, or imprisonment not exceeding six months, or both such fine and imprisonment. Perhaps the only criticism that could properly be made of this statute is that the time should not have been limited to two weeks after birth, but would better have been extended to four weeks, or even to six, or more. Small children not infrequently acquire gonorrheal ophthalmia from the dirty fingers of their mothers, and there is no particular advantage in limiting the period of safety to the time during which the infant is as a rule beneath the care of nurse or midwife. The Missouri statute reads "three weeks."

Leaving the subject of ophthalmia neonatorum, about which very much more could be said, here is a very useful Connecticut statute, which, so far as I know, has never been copied into the laws of any other state:[91] "Every person, firm or corporation using stained, painted, or corrugated glass in factory windows, where the same is injurious to the eyes of the workmen therein, shall remove the same upon the order of the factory inspector."

The various laws requiring the use of blowers, hoods, etc., in connection with polishing machines, etc., have in view almost exclusively the protection of the eyes. Nearly all the states possess such laws at present, and, of these, the following from New Jersey may very well stand as typical:[92] "Sec. 14. All corporations, firms or persons conducting a manufacturing business * * * where emery wheels or emery belts of any description are used, either solid emery, leather, leather covered, felt, canvas, linen, paper, cotton, or wheels, or belts rolled or coated with emery or corundum, or cotton wheels used as buffs, shall provide the same with blowers or similar apparatus, which shall be placed over, beside or under wheels or belts in such a manner as to protect the person or persons using the same from the particles of the dust produced and caused thereby, and to carry away the dust arising from or thrown off by such wheels or belts while in operation, directly to the outside of the building, or to some receptacle placed so as to receive and confine such dust * * *.

"Sec. 15. * * * Each and every such wheel shall be fitted with a sheet or cast-iron hood or hopper of such form and so applied to such wheel or wheels that the dust or refuse therefrom will fall from such wheels or will be thrown into such hood or hopper by centrifugal force and be carried off by a current of air into a suction pipe attached to some hood or hopper."

[91] *General Statutes*, 1902, sec. 4518.

[92] *Acts of 1904*, chap. 64, secs. 14 and 15. (Several of the immediately succeeding sections are also interesting in the present connection.)

Thus much for the legal enactments in the United States tending toward the prevention of ocular injuries and diseases; and, truly, by any one who investigates this class of our legislation at all thoroughly, it is readily perceived that in this country there exists a very great need of further determinate ophthalmo-sanitary legislation. For instance, the sale of explosives for use on the Fourth of July and other holidays should be much more carefully restricted, or, still better, should be prohibited entirely. At present, nearly all such matters are left to local ordinance, whereas each state should enact a statute on the subject, and every state prosecutor should see that the law is strictly enforced within his territorial jurisdiction. A civil statute, making the seller of explosives to persons under age answerable in damages for all injuries resulting from such sale, would exert, beyond question, an extremely deterrent effect. Such a law, for one thing, would not depend for its enforcement on the vigilance of public prosecutors.

Still another matter vainly demanding legislative attention is the fitting of glasses by incompetent persons. It is not perhaps an exaggeration to say that nine-tenths of all the glasses fitted, or misfitted, in this country are obtained from the hands of grossly ignorant men, persons who are not physicians in any sense whatever and who have never received even the slightest medical training. Each of these incompetent persons almost invariably makes himself known throughout the community as "eye-doctor," "eye-specialist," "ophthalmologist," and the like, by which misnomers he succeeds in leading the public to suppose that he is a physician paying especial attention to diseases of the eye. Unfortunately, legislators, forgetting that the only possible justification for the narrowness of specialism is the broadest possible preliminary training in the different general medical branches (from which no specialty can properly be dissevered, except in the field of actual practice) are generally, in fact almost universally, disposed to regard the treatment of eye-troubles by those who are only spectacle-fitters as merely a further and praiseworthy development of the modern idea of specialism. The consequence is that legislation, instead of tending to oust these people from ophthalmic practice, tends yearly more and more firmly to establish them therein.

A number of states now have legislation, the object of which is to fence about and safeguard these unqualified practitioners.

Then another matter demanding attention, but very unlikely to get it, is the continual sale in enormous quantities of eye-drops, eye-salves, eye-batteries, and the like, not only by respectable pharmacists, but also by "wheeling strangers of here and everywhere."[93]

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[93]The subject of the graduate optician, the prescribing pharmacist, and the wheeling stranger will *not* be considered hereafter in connection with

Another deficiency in American ophthalmo-sanitary legislation lies in the fact that, in only two states of all our forty-eight, has any statute been enacted, looking toward the establishment of medical inspection of public school children.[94] The states in question are, New York and Massachusetts. Only in the latter state is the inspection mandatory and state wide. Of all the defects found in school children in this and in European countries, those of vision are by far the most numerous; hence the importance from the ophthalmic viewpoint of inspection in the public schools.

Tests for poor vision and poor hearing are, in Massachusetts, made by the teacher, yet, nevertheless, much good has been accomplished. New York has a somewhat similar statute, but the New York law does not render the inspection obligatory.[95]

Nowhere in the United States, so far as I know, are provisions made for the institution of separate classes for children with defective sight—like the *Nebenklassen* of the Germans—or separate schools for children suffering from trachoma—such as exist in Italy.[96]

Every state should, as a matter of course, provide for medical inspection of its public schools, both by general practitioners and by specialists. The provisions should be absolutely mandatory and state wide in their application. Then, too, although much should, as a matter of expediency and perhaps necessity, be left to the conscience and

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the laws of other countries. Suffice it to say that, in every civilized land on earth, so far at least as I have been able to ascertain, the wail for reform in these matters goes up to heaven continually and vainly. Thus, for a single example, take poor France, as voiced by Chevallereau in the *Encyclopédie française d'ophtalmologie*, Vol. IX, p. 777: "Notre domaine, que d'aucuns trouvent et avec raison déjà étroit, est constamment envahi par un grand nombre de braconniers qui exercent sur nos terres de véritables brigandages. Les pommades et les eaux pour les yeux sont vendus par un grand nombre de pharmaciens, qui, ici comme toujours, se trouvent aux premiers rangs de nos concurrents; les sœurs de l'hôpital de Saint-Germain-en Laye vendent une eau qui guérit la cataracte; un restaurant situé près de la Bastille donne à qui en désire l'eau des Quatre-Sergents qui guérit tout. Ces exemples sont pris entre plusieurs mille.

"L'humeur de nos confrères s'est surtout élevée depuis quelques années contre les opticiens qui ne se bornent pas à exécuter nos ordonnances, mais prescrivent d'eux-mêmes et fournissent des verres pour tous les genres de réfraction * * *."

[94]To be sure, a little has been done, here and there, by virtue of local powers. Thus, school nurses have throughout the country been installed in the public schools of some of our larger cities—always, by the way, with excellent results. See on this head *The Value of the Nurse in the Public School*, by Thomas A. Woodruff, M. D., Chicago, in the *Bulletin of the American Academy of Medicine*, Vol. X, No. 5, Oct., 1909.

[95]For an example of what *can* be done where proper intelligence and determination exist, the reader is referred to an article by F. W. Carruth, entitled *A Municipal Crusade Against Trachoma*, *No. Am. Rev.*, 177: 766-74. This crusade was nobly led by Dr. Richard Derby and Dr. Ernst J. Lederle.

[96]An excellent article on *The Medical Inspection of Public School Children* is that by Dr. G. W. Rice, of Champaign, Ill., in the *Illinois Medical Journal*, for March, 1910, p. 328.

discretion of teachers and inspectors, yet very much might well enough be made a matter of certainty by hard and fast rules. Thus, Javal's dictum that buildings surrounding a schoolhouse should not stand closer to the school than twice their altitude, might very well be insisted on in every case. Again, such matters as temperature and ventilation might be the subject of fixed rules. Inspectors should be required, under appropriate penalties, to see that cards are issued to parents, directing the latter's attention to any defects of a physical nature occurring in their children. Monthly inspections should be required[97] and the occurrence of contagious diseases should be a signal, always, for the removal of the afflicted scholar, or scholars, until such time as his or their reappearance could be made without danger to other persons. School books should be printed in type neither above nor below certain standards of size, and on paper absolutely opaque and of a dull finish. Larger sized type should be required for the younger children and for the bodies of the pages than for older students and foot-notes. In towns of a thousand or more inhabitants there should be separate schools, or classes, for children with defective vision—less, say, than 1/5. Indigent children needing glasses should have these furnished at the public expense.[98] As to school furniture, the front edge of the seat should be required to extend not less than 2 nor more than 4 inches forward of the back edge of the desk; the seat should be at an approximate distance from the desk of ⅛ the pupil's height; the top surface of the desk should be inclined in the direction of the pupil at an angle of 15° to 20°; and certain other regulations relative to school furniture, not possible to be mentioned here, should be made the subject of statutory enactment. Finally, in towns or cities with populations exceeding ten thousand, school nurses should be employed, and should be vested with appropriate and adequate authority.

(2.) Laws which only indirectly, or partly, have for their object the prevention of eye diseases and injuries.[99]

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[97]Our active little neighbor across the Pacific got round to this some time ago.

[98]By which I do not mean at the expense of some individual oculist.

[99]Unfortunately, the employer's liability law which has been enacted in Germany (das Unfallversicherungsgesetz) and, with certain modifications, in various other lands (England, France, *et al.*) has never been copied, except as to a few of its features, into the laws of the United States or of those of any of the seperate States. This law (Unfallversicherungsgesetz) which makes the employer liable at all events, (*i. e.*, irrespective of such questions as contributory negligence, fault of fellow-workmen, assumption of risk, etc.), for accidents to his employes, has had a most excellent effect in the way of preventing injuries to workmen; for, when employers know themselves to be responsible for such injuries at all events, they take the utmost pains to prevent the occurrence of accidents.

For an excellent and somewhat copious discussion of this subject, the reader is referred to the series of articles by Dr. W. H. Allport, of Chicago, in the *Illinois Medical Journal*, for Oct., Nov. and Dec., 1909, entitled *Studies in Contemporary Workmen's Compensation.*

Of these the most important by far are those relating to vaccination, since *variola* is extremely prolific of blindness, even in mild cases of the disease. It would be superfluous to mention the various requirements in the several states relating to the vaccination of school children, but it is well worth knowing that, in Connecticut, Maine, and Virginia, laws are in force which require the vaccination of workmen under certain (generally too limited) circumstances.

Maine has the most explicit law upon the subject, but restricts its application to paper mills. Thus:[100] "Sec. 83. No owner, agent or superintendent of any paper mill where domestic or foreign rags are used in the manufacture of paper shall hire or admit any person to work in or about said mill who has not been successfully vaccinated or revaccinated within two years, or to the satisfaction of the local board of health.

"Sec. 84. No person shall work in or about any paper mill where rags are used, who has not been successfully vaccinated or revaccinated within two years, or to the satisfaction of the local board of health."

The fine for violation of either of these provisions is restricted to a maximum of fifty dollars. Moreover, there is no minimum limit whatever, and the fines are almost always too light. It is easy enough to see why the employes in and about paper mills should be the especial objects of vaccinial legislation, but, certainly, the law should be extended so as to apply to many other classes of workmen.

Connecticut's law upon the subject is also limited in its application to paper-mill employes. Further, it is altogether too short and unexplicit.[101]

Virginia limits the application of her vaccination statute[102] to "Any person, firm or corporation employing large bodies of laborers in the state of Virginia constructing works of public improvement * * *."

The laws of the United States and also of the separate states comprise, nevertheless, a rather large number of provisions, the object of which is, at least in part, to prevent the occurrence of injuries to, and diseases of, the eye. Thus, in some states, the shuttles which shoot to and fro in weaving mills must be guarded from flying out of the looms —which, by the way, they sometimes do at all events, often with disastrous consequences to the eyes of those who are working near. Threshing machines, also, are generally required to be so protected that no "joint, knuckle, or jack" thereof, "is dangerously exposed." Persons charging any "hole with nitroglycerin, powder, or other explosive" are usually forbidden to "use any steel or iron tamping bar." Professional

[100] *Revised Statutes*, 1903, Chap. 18.
[101] *General Statutes*, 1902, Sec. 4693.
[102] *Code*, 1904, Sec. 1743e.

shot-firers are quite uniformly required to shoot down the coal in mines "employing" for instance "twenty or more miners to work in the same." The various regulations requiring an adequate supply of outer air in mines, both for breathing purposes and also for the prevention of explosions due to the accumulation of fire-damp, those, also, providing for a sufficient number of adequate escape shafts, for improved safety catches, for "experienced, competent, and sober men" to have "charge of hoisting apparatus and engines"—all these and many similar regulations have a tendency to prevent the occurrence of injuries to the eyes as well as to other portions of the body. Then there are numerous regulations relating to railways, steamboats, steamships, the construction of buildings, etc., which cannot here even be mentioned by title, partly because of lack of space, partly because of the high degree of technicality of many of the matters involved.

Before we leave this subject, however, we ought to remind ourselves that all the various laws which tend to shorten the hours of labor, and which limit or prevent the improper employment of women and children in industrial occupations are all—so far as enforced—of a very high degree of value not only in the prevention of diseases and accidents generally, but also of those which, either directly or indirectly, have reference to the eye.

Passing to the ophthalmo-sanitary regulations prevailing in other countries than our own we first consider the

Ophthalmo-Sanitary Laws of England.

First of all, there exists in England, as already suggested in a footnote to this chapter, a Workman's Compensation Act (1906) by which is placed upon all employers a tremendous pecuniary responsibility for the safety of their men. One effect, among many,[103] of this act, has been to diminish in a most remarkable degree the number of accidents to laboring men in England. The act provides for compensation not only after industrial accidents, but also in case of the development of certain specified industrial diseases, for example miner's nystagmus and bottle-maker's cataract. In addition to this splendid piece of legislation, there exists a "Factories and Workshops Act" (1901) which has also proved beneficial. It prescribes, among other matters, that every factory must be clean, have a certain amount of air-space for employe, provide adequate ventilation, be of proper temperature, and possess

[103]Dr. A. Maitland Ramsey, of Glasgow: "The design of the framers of the Act was, undoubtedly, to minimize the need for legal procedure; but their purpose in this respect has not been achieved, for no statute of recent times has been more provocative of litigation."—"Eye Injuries: With Special Reference to the Workmen's Compensation Act, 1906," p. 4; reprint from *The Hospital*, Nov. 13, 20, 1909. This article, by the way, is a valuable contribution to the literature of "Visual Economics."

adequate and appropriate sanitary accommodation. There are special regulations relating to all persons working in poisonous substances or in conditions dangerous by reason of steam, machinery, fumes, etc.

With regard to vaccination, there is ample provision for this in general, but any child can be withheld from what has been called "the terrible torture of vaccination" if its parent, or any responsible person standing *in loco parentis,* avows before a magistrate that he disbelieves in the efficacy of the process. No machinery is provided for revaccination *(per contra* in Germany and especially in Italy).

England was the first of all the nations to provide for medical inspection in the public schools (1872); nevertheless in her system of inspection, even at the present day, there is much to be desired.

The medical inspection of school children is, in England, placed in the hands of the Sanitary Department of the local Government Board, the Board of Education having delegated the work to them. The "machinery" is said to be very defective. There are no requirements at all for admission, but the eyes of all children in "State" schools are tested after entrance. No arrangement has ever been made for treating or retesting.

Some special arrangements have been made for school children who see poorly, but nothing of an adequate nature. It is likely, however, that better arrangements will be made soon.

With respect to *ophthalmia neonatorum* we may say that the use of Credé-drops is not at all compulsory on the part of either medical man or midwife. In case the mother was delivered by a midwife, and any inflammation or discharge appears, the midwife is obliged to report the fact at once to "any qualified medical man," the choice of the particular man being left to her.

Ophthalmo-Sanitary Laws in France.

In France, as in England, there exists an excellent Workmen's Compensation Act (that of Feb. 9, 1898), which has been amended and revised until as late as March 31, 1905.

As this law now stands, it provides for indemnity after industrial accidents *(accidents du travail)* no matter to whom the occurrence of such accidents is due, excepting only when demonstrably the result from the inexcusable negligence of the injured person himself. This law applies to all industries operating in any way by means of machinery, excepting only such machinery as is run by man- or animal-power. Further, the work of the injured employe must be interrupted for more than four days.

Twenty-four hundred francs is the maximum earning capacity which is used as a basis for full computation; all overplus is computed

at one-fourth. For partial or temporary disability the workman receives one-half the reduction in his wages; for total and permanent disability, a pension equal to two-thirds the amount of his earnings. Pensions are revisable, after three years, the degree of disability being, of course, in many cases subject to change.

In case of the workman's death, 100 francs is paid as funeral expenses. Then, in addition, a pension of 20 per cent of the wages of the deceased is allowed to the widow, and, to the orphans, 40 per cent for the loss of one parent and 60 per cent. for both. Dependent relatives, if there be no surviving child or widow, may receive a pension equal to 30 per cent the wages of the deceased.

Objection has often been made that the law in question has rendered difficult the securing of employment by married persons, especially if these have children. A further objection is sometimes offered that it provides no compensation for disfigurements which do not interfere with the earning capacity. In general, however, the law has been satisfactory (like similar laws in other lands) not merely to employes but also to employers.

In addition to the Workmen's Compensation Act—which has proved so beneficent in the way of preventing injuries of almost every kind—there exist in France numerous laws, or regulations, for the prevention of accidents and diseases. These provide for adequate heating, lighting and ventilation in factories, etc., for cleanliness, for proper water-closet facilities and protection from the action of numerous poisons (lead, methyl alcohol, etc.) and from steam, heated metals, electricity and various sorts of machinery. All these matters are under the control of the Ministry of Labor.

Vaccination is compulsory for all persons, civil and military, and revaccination for the military.

All contagious diseases must, in a manner of speaking, be reported. "Facultatively" reportable[104] are the conjunctivitis purulenta of adults and ophthalmia granulosa. Among the diseases for which are required both reporting and disinfection, is ophthalmia neonatorum.[105]

There is, in France, an excellent system of medical inspection in the public schools. The medical inspector does not, indeed, himself take charge of the treatment of the ailing children, but he is obliged to report to parents the physical defects of such of their offspring as are attending the public schools; and the parents take the child to some physician of their choice. However, (and this is a point worthy of extensive imitation) the parents are obliged to see that the child is treated, and by some registered physician. The child cannot return to

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[104]Decree of Feb. 10, 1903.
[105]Law of Feb. 15, 1902, art. 4.

school without the permission (after careful examination) of the medical inspector.

There are no separate schools or classes for trachomatous pupils, the reason, as stated by an eminent French authority,[106] being that trachoma in France is not a sufficiently common disease to render such arrangements necessary. The rule is to permit to remain in the schools all trachomatous pupils exhibiting little or no conjunctival secretion, and to remove all those in whom these secretions are particularly abundant.

The prescription of glasses for school children is looked after, when necessary, and, in some cities, children who see poorly are grouped in special classes. Special schools for children with defective sight are not established, because, it is said, of the distance which children of this sort would then be obliged to go in order to get to school.

The hygiene of the lower schools is controlled by local boards, that of the high schools by the Ministry of Public Instruction.

Midwives are obliged to report at once any discharge or inflammation from the eyes of an infant. The report is made, in Paris and Lyons, to the prefecture of police; elsewhere, to the "maire." The use of Credé-drops is compulsory in all cases, irrespective of discharge or inflammation.

Finally, *"le livret à famille"* hands to all newly married couples a printed card, or circular, containing instructions with regard to the above-mentioned and various other matters.

Ophthalmo-Sanitary Legislation in Germany.

In Germany, as one might readily suppose, the subject of ophthalmo-sanitary legislation has, in common with sanitary legislation of a general character, received a good deal of attention. It would be impossible to elucidate completely here even the more salient matters of this kind of legal enactments in Germany, but a few of the more peculiar (and, at the same time, I think, sensible and scientific) features may simply be pointed out, practically unaccompanied by comment.

The Prussian sanitary corps is organized as follows: Each county (Kreis) has its Kreisarzt,[107] or official physician, for the county. Next each province has its *"Provinzial-Medizinal-Collegium,"* or Provincial Medical College. Over this is the *"Wissenschaftliche Deputation,"* the highest consulting body of the corps. This last-named body, however,

[106]Chevallereau, in *Encyclopédie français d'ophtalmologie*, Paris, 1910, Vol. IX, p. 545.

[107]The classic work on the functions of the Kreisarzt is Schlockow, "*Der Kreisarzt.*" In general, these functions are to supervise all public sanitary institutions, asylums, etc., also the registers of physicians, pharmacists, midwives, etc. Their court-work is restricted to certain police-evidence.

is a branch of the *"Abteilung für die Medizinalangelegenheiten"*—itself a branch of the ministry *"der geistlichen Unterrichts-und Medicinal-Angelegenheiten."* In addition to all these there exist in certain cities *"Gerichtsärzte,"* or "Physicians before the Courts," who are often called upon as experts by the State's Attorney.

Taken altogether, the medical corps is, in Prussia, a many-ranked hierarchy. Its work, however, I understand, is very thoroughly carried out.

Vaccination, to begin with one of the most important matters, is absolutely compulsory in the first year of life, and re-vaccination in the twelfth.

Trachoma, diphtheria, small-pox (the little there is to be found of this last-mentioned disease) must be reported to the police on official cards throughout Germany. There is also a Prussian law[108] which, during epidemics, renders obligatory the treatment of certain diseases, among which trachoma is here especially noteworthy.

The use of Crédé-drops is nowhere compulsory, but a peculiar feature of the law relating to *ophthalmia neonatorum* (characteristically German, too, though a similar practice now prevails in France) is that in many of the cities, notably Berlin, printed instructions concerning the matters in question are handed over to newly married couples.[109] In some of the cities the printed card is not handed over until the first birth is reported—when, of course, it could do no good in the way of prophylaxis, unless indeed as to the eyes of later-born children.

The medical inspection of the public schools is very different in different localities. All the larger and many of the smaller towns employ "school-doctors" not only for the public, but also for some of the private schools—gymnasiums, etc. In Berlin there are 56 school-doctors, each controlling about 5,000 children.[110] All children are tested when they enter, and, at intervals, later. Whenever the necessity exists, the children are sent to public or private dispensaries. When the parents are poor, the children's glasses are paid for by the city.

Children with defective vision are put into extra classes—the so-called *"Nebenklassen."* The results of this arrangement are exceedingly satisfactory. However, the vision must be less than 1/10, which is a slight drawback. Other children are, as with us, turned over to the blind-schools. The treatment of the children is compulsory on the parents. A doctor treating a case of trachoma must, as above-men-

[108]That of Aug. 28, 1905.

[109]One can hardly conceive of such highly sensible, albeit blush-producing, measures being adopted in the land of the free and home of the brave and often unnecessarily blind.

[110]I am credibly informed that each of these "school-doctors" in Berlin is paid, for looking after his 5,000 youngsters, only 2,000M. annually—less than 500 dollars!

tioned with regard to trachoma in general, report the case to the police on an official card.[111] The police re-report the matter to the Kreisarzt, and this latter functionary sees that the patient takes his treatment and that the doctor's various instructions are actually carried out.

Indirectly tending toward the prevention of injuries to, and diseases of, the eye, is the excellent *Unfallversicherungsgesetz,* which, as already mentioned, has been so widely copied in the legislation of other lands. It would be impossible here, owing to limits of space, even to sketch in outline this very thorough and far-reaching law; we may, however, direct attention to a few, only, of the most characteristic features.

The law provides, then, in effect, for the insurance of all, or nearly all, workmen by their employers. The system consists of two divisions—the federal, and the state. The federal division is organized as a department of the Bureau of the Interior. The state divisions are organized as bureaus of insurance in each of the Bundesstaaten. The state bureaus control the industries within the state, and the federal bureau those of a national, or interstate, character. Every bureau—the federal bureau, as well as the different state bureaus—"collects statistics, makes rules, and constructs reports, and serves as a court of final appeal." Subordinate to the various bureaus are the "Courts for Industrial Claims," the personnel of which consists of one government official (President) and two representatives each, from the employers and the workmen. These courts appoint medical examiners who make reports and who also testify before the court, if there be necessity therefor. The parties themselves may choose the experts, if they so desire. There is no jury.

The fund from which the claims are paid is held by trustees, and is composed chiefly of assessments paid into the fund at stated intervals by the various employers of the nation, grouped into definite units. The various awards, pensions, expenses, etc., are paid through the Post-Office Savings Bank, and there is no such thing as a judgment being worthless by reason of insolvency on the part of any individual employer.

There also exists, by virtue of this same law, insurance against sickness, old age, invalidism and the first thirteen weeks of disability resulting from accident. The benefits, however, of this "Sickness Insurance Fund" are available only to manual laborers earning not to exceed 2,000 marks yearly.

In addition to this Workman's Compensation Law—which has

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[111]Teutonically thorough is the requirement that complications, origin, nativity, and many other matters must be stated on the card.

had the effect of causing employers to take the utmost possible precautions against accidents—there exist the regulations of the various unions (Berufsgenossenschaften), which regulations are nailed upon the walls of factories, mines, etc. Infraction of these rules is fined heavily—as high indeed as to 1,000 marks.

Ophthalmo-Sanitary Legislation in Italy.

In Italy the legislation for the prevention of ophthalmic, and other, injuries or diseases, is not so thoroughgoing, quite, as it is in Germany. Yet, in many respects, it is better than similar legislation in the United States.

The sanitary organization is very good indeed—complete and yet not cumbersome. The actual supervision of the public health is delegated to Communal Physicians (Official Sanitarians) while, over these, are the Physicians of the Province, who, in turn, are subordinate to the General Bureau of Health, which forms a part of the Ministry of the Interior. There exist also Provincial Sanitary Councils and a Superior Council of Health.

Vaccination is obligatory for all children in the first six months of life. It must be repeated whenever the sanitary authority deems a repetition necessary. Admission to schools, factories, and various classes of institutions is absolutely barred, except to persons who have been properly vaccinated.[112]

All persons taking up their domicile in the Commune of Milan (and the same regulation exists in certain other communes) must submit at once to vaccination unless indeed he has been successfully vaccinated within six years.

Among other diseases which have to be reported are the following, important from an ophthalmic viewpoint: Trachoma, diphtheria, small-pox, typhoid fever, and syphilis when that disease has been communicated by "mercenary intercourse." There are no formal official cards, however, providing for a large amount of detailed information, such as are used in Germany. The sanitarian is simply required to report "the necessary indications." Trachoma, furthermore, does not have to be reported. It is only fair to add, though, that the sanitary authority can, when he believes it to be necessary, render the reporting of this disease obligatory. And that has now and then been done, when a severe and wide-spread epidemic of trachoma had appeared.

quirement. Further, the maximum and minimum limits d onot have

In the regulations concerning rosiculture, trachoma is regarded

[112]Regolamento sulla vaccinazione 29 marzo 1892 ed art. 130 della legge sanitoria 1 agosto 1907.

as a reportable disease.[113] The patient is always isolated. In this kind of cultivation, I am informed, there is a great foregathering of workmen from very many places.

Midwives are not obliged by law to report "any redness or inflammation of the eyes," but, as a rule, they do actually report these matters (in accordance with certain instructions issued to all who practice midwifery) to physicians, and then the physicians are obliged to make a report of the case. Midwives are also instructed to wash the lids and inward parts of the eyes of all newly-born children with boric acid lotion, and then, if, in spite of these precautions, an inflammation develops, to report the matter, as above stated, to some qualified physician.

No printed cards relative to ophthalmia neonatorum are handed over to newly-married couples, as is done in France and Germany.

No certificates relative to the sight are required for admission to the schools. All the communes, however, have their schools inspected medically at least once per month, thus, in the matter of frequency, setting a splendid example to nearly all civilized lands. If contagious diseases are discovered, all the afflicted pupils are removed until such time as the reappearance of such pupils can be made in the schools with perfect safety to other students. The matter is chiefly left to local supervision, but the governmental sanitary authority also has the power to carry out the inspection himself.

In some of the communes oculists, as well as general practitioners, are employed to inspect. In general, however, the law pays little attention to matters of sight, but lays most stress on the subject of contagion. Very much is left, in every jurisdiction, to the discretion of the teacher and the visiting physician.

There are no separate classes for children with defective sight. Separate schools (or classes) however, exist in the larger communes for children afflicted with trachoma.

The excellent German *Unfallversicherung,* already adverted to in this chapter a number of times, has stood as a model for similar legislation in Italy, as in so many other countries. This insurance law has special application in Italy to industries in which machinery is used, and in which the number of workmen employed exceeds five. Crews of ships are also insured. Agricultural laborers are not insured, excepting those occupied in the use of machinery. The law, I understand, "works well and is severely applied." It has also "prevented hosts of accidents."

In addition to this very beneficent compulsory insurance law,

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[113]Art. 13 del Reg. 29 marzo 1908.

there exist in Italy numerous regulations for the prevention of mischances in various sorts of industries. A discussion of these would lead us far afield. Suffice it to say that, in Italy, almost every form of injury by machinery, explosive substances, poisons, etc., etc., has been brought within the prevision of the law. . .

IV.

MALPRACTICE.

Surgery means snags, and he that does much surgery will sooner or later discover himself entangled in snags of a legal kind. To this rule the surgery of the eye is by no means an exception; it is, in fact, rather an exaggerated instance of the working of that rule. The largest proportion of malpractice suits, to be sure, grows out of fractures and dislocations[114], while obstetrics as a fruitful field for damage suits comes clearly next in order, but then, as class three, and close to the two preceding categories, comes the surgery of the eye.

The reasons for this high degree of liability in the case of ophthalmic surgery are exceedingly numerous. Suffice it to state three: (a) The delicacy and great importance of the organ on which such surgery is done. (b) The rather large amount of surgery which is necessary in connection with the treatment of diseases of the eye. (c) The special responsibility imposed by the law (at least in the United States and England) upon any one who professes to be a specialist.

In the discussion of the subject of ophthalmo-surgical malpractice, precedence will be given—as was done in the case of the ophthalmic expert witness—to

A.—LEGAL CONSIDERATIONS REGARDING MALPRACTICE.

Legal Considerations Regarding Malpractice in the United States.

In the United States—as indeed in almost, but not quite, every civilized country—this one basic proposition underlies the entire law of malpractice, namely, that a physician is never legally required to respond to a call for professional assistance, if (a) he is not a governmental officer and thereby under official obligations, or if (b) he has not already established relations with the case. This is precisely to the contrary of the popular impression, but is nevertheless the law.

[114]This, at least, is true in the United States. In Germany, I understand, malpractice suits arise most often from obstetrical procedures. See, for example, Gottschalk, "*Gerichtliche Medicin,*" p. 271: "Von den Anklagen wegen Kunstfehler nehmen aber an Zahl die erste Stelle ein diejenigen gegen Geburtshelfer." The statement accords with the generally received opinion that deformity of the female pelvis is commoner by far in Germany than in the United States.

Says Wharton:[115] "No question can exist as to the legal right of a physician, unless he be an officer of the government charged with specific duties, which he thereby violates, to decline to take charge of a particular case." A recent Indiana case[116] well illustrates precisely how free a physician is to refuse to take charge of a case. Here the physician, who had been the patient's family practitioner, refused, admittedly without reason, to respond to the call of a man who was intensely sick, although he (the doctor) had confessedly been tendered the fees for his services in advance, and although he knew that no other physician could possibly be procured in time to be of service to the patient, and that, if he (the physician in question) did not respond, the patient would probably die in consequence. The sick man did actually die, and, as alleged, in consequence of the physician's non-response to his call. There could hardly have been a stronger case against the physician, were the law other than it really is. But said the court: "The act is a preventative, not a compulsive, measure. In obtaining the state's license (permission) to practice medicine, the state does not require, and the licensee does not engage, that he will practice at all or on other terms than he may choose to accept. Counsel's analogies, drawn from the obligations to the public on the part of innkeepers, common carriers, and the like, are beside the mark."

When, however, a physician once takes charge of a case, certain responsibilities attach to his work immediately and by implication. No express agreement to be responsible for this or that is at all necessary in order to render him responsible. On the other hand, with one exception, he cannot evade his professional liabilities by any sort of contract whatever, however express and however explicit. Contracts made in advance of treatment or operation, with a patient, or with a patient's parent or guardian, that the physician is not to be sued for malpractice, are universally held to be "opposed to public policy" and therefore void.[117] The one exception is where a physician declares to the patient his inability to treat the case properly (as, for instance, in many instances, where a specialist is recommended) and yet the patient insists that the physician proceed to do the best he can. In such circumstances the patient is estopped from complaining afterward that the case has not been treated properly—provided, of course, the physician has really done the best he could.

On the other hand, although, as we have seen, the physician cannot, generally speaking, diminish, either in number or extent, the liabilities which the law imposes on him, he can very easily (and often

[115]*On Negligence*, Sec. 731.
[116]Hurley Admr. v. Eddingfield, 156 Ind. 416.
[117]Nor does treating a case gratuitously at all diminish the physician's liability for malpractice.

to his sorrow) very greatly enlarge them. And he can also lessen his rights, as well as increase his liabilities. A very common instance of lessening his rights results from the "no cure no pay" agreement. In this instance, if the patient is not cured he does not have to pay; the physician has lost his right of action against him for the fees. An instance where the physician voluntarily enlarges his liabilities results from the "guaranty to cure." This highly important arrangement is a very different affair from the "no cure no pay" agreement, though, as a rule, physicians confound the two together. When a physician guarantees to cure, he *must* cure, or "pay the difference." That is a very different consequence, as will at once be noted, from merely losing one's fees. To illustrate: If a physician operates for cataract, and guarantees to restore to the operated eye its vision, then, if the sight be not restored, the measure of the damages is precisely what the sight of that eye would have been worth. A jury may assess this value at thousands of dollars.[118]

Now, what are these responsibilities that attach to a physician immediately upon his acceptance of a case, and by implication irrespective of any express contract? They are:

1. Properly to continue his attendance.
2. To possess a reasonable degree of learning and skill.
3. To use that reasonable degree of learning and skill.
4. In cases of doubt, to use his best judgment.

Of each of these duties, we will treat in the order indicated, and, later, of certain miscellaneous affairs of importance in connection with malpractice.

1. As to the physician's duty properly to continue attendance, we may say, briefly, that, in no instance, may he discontinue his treatment, unless (a) the patient discharges him, (b) the patient consents to the discontinuance, (c) the physician gives timely notice so that the patient may employ another doctor in due season, (d) when the patient is no longer in need of the physician's services.

2. The physician's second duty, when he has once taken charge of a case, is to possess a reasonable degree of learning and skill. Of course a physician is not responsible merely for the failure to cure. He is responsible only for the failure to possess (or to use) a reasonable degree of learning and skill. The question unavoidably arises,

[118]It is a general rule of contract that, when a party has, for a consideration, agreed to deliver a certain article—whether iron rails or eye-sight—and has failed to deliver it, he must pay to the injured party the value of the article in its stead. Returning the compensation may, in the case of some contracts, be precisely equivalent to payment of the value of the article, but (as in the case of failure to restore to a cataractous eye its sight) it may fall short of so doing by several thousand dollars.

What constitutes a reasonable degree of skill and learning? In the United States, there exist on this important head three very different rules:

a. The physician is bound to exercise that degree of care and skill which prevails in *the particular locality* in which the given case arises.[119] This rule is not much followed.

b. The physician is bound to exercise that degree of care and skill possessed by physicians in *such localities generally*.[120] In this case, the court said, speaking with regard to the first of the rules on this subject, namely, the "particular locality" rule: "There might be but few practising in the particular locality, all of whom might be quacks, ignorant pretenders to knowledge not possessed by them, and it would not do to say, that, because one possessed and exercised as much skill as the others, he could not be chargeable with the want of reasonable skill." According to this second, or "similar localities" rule, the physician practising in a large city is bound to possess a higher degree of skill and knowledge than physicians who practise in the smaller cities and those in the smaller cities than those who practise in the villages and the country. This second rule is the prevalent rule, by far.

c. Some of the lower courts have attempted to establish a yet higher standard of professional knowledge and skill, a standard which has been expressed in the following language: "Such skill and diligence as are ordinarily exercised by *thoroughly educated physicians and surgeons.*" No court of last resort, however, in the United States, has yet sustained this rule.[121] However, the tendency is, with the continued improvement in medical education, for the courts to approximate more and more closely to this very high standard of medical and surgical requirements.

Now, all these three rules (the second, as before stated, being the prevailing one) apply to general practitioners only. A question of especial interest of course arises here: What is the standard of requirement in the case of specialists, ophthalmic surgeons, for instance?

It is undoubtedly a fact that a specialist (and, in this connection, a specialist is any one who holds himself out, in effect, to be such) is bound to a higher degree of skill than is a general practitioner. The rule is that a person assuming to be a specialist must really pos-

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[119]Hathorn v. Richmond, 48 Vt. 557.

[120]Gramm v. Boener, 56 Ind. 497.

[121]Unless we except the Supreme Court of Pennsylvania in McCandless v. McWha (22 Pa. St. 26). In this case Woodward, J., defined "reasonable skill and diligence" to be "such as thoroughly educated surgeons ordinarily employ." It is a question, however, whether this definition is not merely *obiter*. Further, the case is by no means recent; its date is 1853.

sess and actually use the ordinary learning and skill possessed and used by others who practice the same specialty or specialties in similar localities. Even in the case of a specialist, however, practising in a city of the very largest class, the degree of skill required is by no means such as would enable him to effect a cure in every case that comes before him. There is, in other words, on the part of the specialist no implied warranty to cure any more than there is in the case of the general practitioner. A warranty to cure can arise only from an express contract—a contract which, however, as every body knows, even with all its possible disastrous legal consequences, certain physicians are nevertheless unwise enough to enter into. The law does not attach legal consequences, either to general practitioner or to specialist, merely for failure to cure. It is to malpractice—the failure either to possess, or to use, the proper degree of knowledge and skill (which varies according to locality, specialism, etc.) that the law attaches such consequences. The leg or the arm, or the ear or the eye, must have been improperly treated or in some way neglected, in order to constitute malpractice.[122]

The effect of this principle is very far reaching. In Stern v. Lanng,[123] for instance, Dr. Lanng, an oculist, had removed a chalazion from the left lower eyelid. He had made on the conjunctival surface of the lid a crucial incision down into the cyst, and, after removing the gelatinous contents of the growth, had used a tiny scoop for the removal of the sac. Finally, he had cauterized the cavity by means of a stick of nitrate of silver "about an inch in length" and "about the shape of a lead pencil." The eye itself became much inflamed, and solutions of atropin and boric acid were employed to combat the inflammation and for disinfecting. The lid became adherent to the cornea, and the cornea became opaque. In consequence of the corneal opacity the eye was entirely blind. At the trial three expert oculists pronounced the treatment proper. Said the judge in the higher court: "The inflammation of the cornea, and consequent opaqueness, is ascribed by the appellant to the cauterization of which he complains, but this is not sustained by the testimony. There are, we are informed, a number of causes for it, and that it is impossible to look at the eye and tell whether it has been burnt or not * * *. The result of the treatment is not all that is necessary to recover. It must be made evident that there was negligence or want of skill. There was intense pain felt by plaintiff after the incision. It does not necessarily

[122]And, need we add, damage of some sort must actually have followed from such unskilfulness or negligence, in order to entitle the patient to recover. Otherwise, it is *injuria absque damno*, wrong without damage, and this is not actionable.

[123]106 La. 736.

follow, as we infer, that it was owing to the negligence or unskillfulness of the physician." The judgment which the defendant had obtained below was therefore affirmed.

Another leading eye case on this point is that of Pettigrew v. Lewis *et al.*[124] The plaintiff, a school teacher, alleged that an operation had been performed on her left eye by the defendants (partners) for strabismus, and that the operation had been performed so negligently and unskillfully "that her eye became sore and weak, rendering her unable to complete her education or to perform ordinary household work." She further alleged that she "suffered and still suffers great physical pain in consequence of the unskillful operation and treatment, which has continued to increase since the time of the operation." The lower court, however, sustained a demurrer to the evidence, "holding that it was insufficient to establish a liability against the defendants * * * and gave judgment accordingly." The plaintiff took the case to the Supreme Court, there urging "that the testimony offered by her was sufficient to take the cause to the jury." But said Justice Johnston: "We agree with the district court that it [the evidence] did not show the operation to have been unskillfully and negligently performed, nor yet that the present condition of her eyes was the result of the operation that was performed. No proof was offered of the instruments used or the manner in which the operation was performed. No medical or scientific evidence was offered showing the cause of the present condition of the plaintiff's eyes, nor that the defendants were negligent or careless in the performance of the operation. In fact no witnesses having special skill or knowledge with reference to the treatment of the eyes were introduced in behalf of the plaintiff. The burden rested on the plaintiff to show a want of due care, skill, and diligence in the operation, and that the defective condition now existing is the result of such want of care, skill, and diligence."

Now the degree of learning and skill which the specialist does really need to possess and actually to employ in order to escape the legal consequences which the law imposes upon a specialist guilty of malpractice, is, as already stated, such a degree as is ordinarily possessed and actually used by specialists (not general practitioners) practising the same specialty, or specialties, in similar localities.

A couple of illustrations may possibly here be useful. In Feeny v. Spalding[125] the defendant was a distinguished oculist who practised in Portland, Me. While on a trip to Machias he stopped over for a short time at Cherryfield. Here a girl, seven years of age, cross-eyed

[124] 48 Kan. 78.
[125] 89 Me. 111.

since she was a year and a half old, was brought to him for examination and treatment. After a conference with the parents, the defendant performed a surgical operation on one of the plaintiff's eyes. The plaintiff alleged that, prior to the operation, the sight of the eye on which the operation had been performed, was at least fairly good, but that, after the operation, it was entirely wanting. She further alleged that this result was produced by the defendant's ignorance, want of skill, and carelessness in the performance of the operation. The plaintiff, in the trial court, had received a verdict. Said the court: "It was encumbent on her [the plaintiff] to prove that the injury complained of was caused either by the defendant's want of that degree of skill and knowledge which is ordinarily possessed by physicians who devote special attention and study to the treatment of the eye, or by his failure to exercise his best judgment in the application of his skill to the particular case, or by his failure to use ordinary care in the performance of the operation, and in giving such instructions as should have been given by a surgeon who was only to perform the operation, and who was temporarily in the locality where the patient lived * * *. At the trial, the plaintiff relied almost entirely upon the result which it is claimed followed the operation * * * while the expert testimony on the part of the defence was to the effect that an examination of the eye showed conclusively that the defective vision had existed from birth and that it was as good at the time of the trial as it ever had been * * *. Even if there was sufficient evidence to authorize the jury to find for the plaintiff upon this question, such a finding was not sufficient to warrant a verdict for the plaintiff, when there was no evidence of any want of the requisite skill, knowledge, or care upon the part of the defendant."

Still another case is that of Baker v. Hancock.[126] Here the defendant was a specialist in the treatment of cancer. Plaintiff alleged that defendant had placed upon his nose a substance by "which the end of his nose was eaten off." The verdict below was for the defendant, but the higher court reversed the judgment and remanded the case for a new trial, saying: "Scientific investigation and research have been extended and prosecuted so persistently and learnedly that the person affected by many forms of disease is of necessity compelled to seek the aid of a specialist, in order to secure the results thereof. The local doctor, in many instances, himself suggests and selects the particular line which the general practitioner, in rural communities especially, has neither time nor opportunity to acquire. (Small v. Howard, 128 Mass. 131.) Being employed because of his peculiar

[126] 29 Ind, App. 456,

learning and skill in the specialty practised by him, it follows that his duty to the patient cannot be measured by the average skill of general practitioners. If he possessed no greater skill in the line of his specialty than the average physician, there would be no reason for his employment; possessing such additional skill, it becomes his duty to give his patient the benefit of it. The appellee, if he held himself out as a specialist in the treatment of cancer, was bound to bring to the discharge of his duty to patients employing him as such specialist that degree of skill and knowledge which is ordinarily possessed by physicians who devote special attention and study to the disease, its diagnosis and treatment, having regard to the present state of scientific knowledge. This is the degree of skill which, by holding himself out as a specialist, he represented himself to have; and it does not lie with him to assert, after securing employment and compensation on that basis, that his representation was not true."

In any case, however, whether the defendant is city or country general practitioner or city or country specialist, the degree of skill and learning required has reference always to "the present state of medical and surgical knowledge." This legal proposition is illustrated clearly in Peck v. Hutchinson.[127] The plaintiff, as alleged, had had "infection of conjunctivitis and blennorrhea," together with a perforating ulcer of the cornea and prolapse of the iris. Defendant had operated on the eye, and, as alleged, had used "too large a knife," etc., etc. A matter which bulked very largely at the trial was that, in the course of the operation, the plaintiff had suddenly jerked her head about, causing the production of a false incision, deep and long, directly across the cornea. To this unfortunate movement the defendant attributed the non-success of his operation. The plaintiff, in her turn, contended that the movement was unavoidable by reason of the fact that the work had been done under local, instead of general, anesthesia. The plaintiff's counsel was allowed to read from Wells's "Treatise on the Eye" the remarks by that author on the subject of iridectomy. In the course of these remarks the author states that, for iridectomy, chloroform should always be administered. He does not even mention local anesthesia. In accordance with the views of this book, the counsel for the plaintiff declared that the defendant had neglected his duty, inasmuch as he had operated with local anesthesia only. But said the higher court: "The book was published in 1880 * * * the operation was performed in 1886, and it is claimed

[127] 88 Iowa 320, 55 *N. W. Rep.* 511 ("N. W. Rep." stands for "*Northwestern Reporter*," a convenient periodical, published by a private company, but containing in each issue the latest decisions of the courts of last resort in various northwestern states. It appears sooner, and is often more accessible later, than the official state reports. There is also a "*Southwestern Reporter*," a "*Southeastern Reporter*," etc.)

that, after 1880, and prior to 1886, great changes had occurred in optical surgery; that during that time, cocain, a local anesthetic, was discovered, and came into use, thus superceding the use of general anesthetics in such cases. This may be conceded * * * that fact was fully shown to the jury. 'Physicians and surgeons are required to use ordinary skill and diligence * * * having regard to the improvements and advanced state of the profession at the time of the treatment.'" The judgment, which, in the lower court, had been for the plaintiff, was, therefore, by the higher court reversed.

Here is a still further point in connection with the question of what constitutes a reasonable degree of learning and skill. The matter is always to be tested by the doctrines of one's own school of practice. This legal proposition is absolutely indisputable, having been decided in a very large number of cases, with, so far as I know, not a single dissenting case.[128] The principle is, in fact, not merely good law, but it is also good sense. So long as the law gives recognition to various so-called "schools," it must, as a natural consequence, allow the treatment of any given physician to be tested by the doctrines of the school he professes to practice. To hold a regular practitioner culpable for ignoring the principles of, say, homeopathy or of eclecticism, or an osteopathic physician for not proceeding according to the principles of regular medicine or of homeopathy, would be, in effect, not merely to violate the compact made with the State when the physician was granted a license to practice, but also to break the contract made by implication between the patient and the practitioner when the latter was employed in the case.

The rule, however, does not apply to the case of a clairvoyant or of any other person who practises a system which has no recognition under the law and nothing definite in the way of rules and principles. Thus, in Nelson v. Harrington,[129] said Lyon, J.: "To constitute a school of medicine under this rule, it must have rules and principles of practice for the guidance of all its members, as respects principles, diagnosis, and remedies, which each member is supposed to observe in any given case. Thus, any competent practitioner of any given school would treat a given case substantially the same as any other competent practitioner of the same school would treat it. One school may believe in the potency of drugs and blood-letting, and another may believe in the principle *similia similibus curantur;* still others may believe in the potency of water, or of roots and herbs; yet each school has its own peculiar principles and rules for the government of its

[128] This rule, however, has never been adopted, at least so far as I have been able to ascertain, in any of the countries of Continental Europe.
[129] 72 Wis, 591. Cited also *supra*, under another legal proposition,

practitioners in the treatment of diseases. Not so, however, with the clairvoyant practice. True, the practice has but one mode of ascertaining what the disease is, and the remedy therefor. This mode has already been stated. But the mode in which a physician acquires a knowledge of his profession has nothing to do with his school or system of practice. One person may acquire such knowledge from certain books; another from certain other books, which perhaps teach different principles; still another from oral communication, as lectures, *et cet.*, or from experience alone; and still another from his intuition when in an abnormal mental state; yet these differences do not necessarily constitute separate schools of medicine."

This was "a case of first impression," (as mentioned by the learned justice himself in his opinion) but it is now the settled law.

3. Now it is, furthermore, absolutely necessary that a doctor, whether his field of work be limited or unlimited, and whether his practice be chiefly in the city, or in a town, or in the smallest country village, not merely possess, but that he also actually make use of the skill and learning which the law requires him to possess in accordance with the rules above stated. He must not be negligent, however skillful he may be. He must actually exercise his skill. Otherwise he is guilty of malpractice.

It is not essential that this division of the general subject be greatly amplified, but here it is certainly important to lay some stress on a matter which should prove of interest to oculists, who, as a rule, do rather a great deal of innovating. I refer to the matter of experimentation. On this head, the general principle is quite clear: Thou shalt not experiment on mankind. The use of new and untried remedies or new and untried operative procedures, are alike forbidden, in the case of man. The view of the law is that experimentation should be conducted on the lower animals. Just what would happen to medical progress in case our friends, the antivivisectionists, should carry their point, and experimentation on animals should be forbidden also, as well as that on man, is a trifle unpleasant to think about. Possibly, in the words of Micawber, we should "progress in a retrograde direction." However, the matter is not so bad as it looks in the light of the general rule. There is one exception: The doctor may innovate in the case of an unusual disease (pellagra, for example) or of new and unusual combinations of symptoms in old diseases. Even in such cases, however, he must be altogether able and ready to prove that his innovations were not haphazard, but that they were based on things already known and that they were carried out in accordance with a definite and sensible theory of some benefit to accrue to the sub-

ject of the experiment himself.[130] Said the court, in Jackson v. Burnham:[131] "There must be some criterion by which to test the proper mode of treatment in a given case; and, when a particular mode of treatment is upheld by a consensus of opinion among the members of the profession, it should be followed *by the ordinary practitioner;*[132] and if a physican sees fit to experiment with some other mode, he should do so at his peril. In other words, he must be able, in the case of deleterious results, to satisfy the jury that he had reason for the faith that was in him, and justify his experiment by some reasonable theory." Again, in Carpenter v. Blake,[133] said the court: "Some standard by which to determine the propriety of treatment must be adopted; otherwise experiment will take the place of skill, and the reckless experimentalist, the place of the educated, experienced practitioner. If the case is a new one, the plaintiff must trust to the skill and experience of the surgeon he calls; so must he if the injury or the disease is attended with injury to other parts, or other diseases have developed themselves, for which there is no established mode of treatment. But when the case is one as to which a system of treatment has been followed for a long time, there should be no departure from it, unless the surgeon who does it is prepared to take the risk of establishing, by his success, the propriety and safety of his experiment."

Of course the great defect of the law with regard to the matter of experimentation and innovation (medically speaking—we admit that the subject is difficult) lies in this one point, namely: That it makes no kind of provision whatever for the finding out of new and more perfect methods of treatment in old and well-known diseases presenting old and well-known combinations of symptoms. For instance, an oculist desires to ascertain whether the injection of certain substances into the anterior chamber of the eye will result in the complete absorption of a senile cataract. Now, senile cataract is by no means a "new" disease, but perhaps older than the human race itself, and, furthermore, for this condition there exists a well-established line of operative treatment. Yet, to forbid the innovator from trying his injection (with or without previous animal experimentation, according to his judgment) would, be-

[130]In this connection the words of Aristotle with reference to the Ancient Egyptian law, are interesting: "Even in Egypt the physician was allowed to alter the mode of cure which the law prescribed to him, after the fourth day. But if he did so sooner, he acted at his own peril."—*Politics*, Book III, c. 15.

[131]20 Col. 533.

[132]These words (which have been italicized by the present writer) are, though *obiter dictum*, extremely interesting. They suggest this question: Have some practitioners a better right to experiment on human subjects than have others?—a question which, so far as I have been able to ascertain, has never appeared for direct decision in any court of last resort.

[133]60 Barb. 488. ("Barb." is short for "Barber." The Barber reports are certain N. Y. reports which bear the name of their reporter.)

yond question, be to hinder the onward march of medicine. Even though the results of the experiment should be unfavorable to the individual, something might very conceivably have been ascertained that would prove immensely serviceable, indirectly at least, in many an after case. Of course, there should be a reasonable chance that the innovation would prove to be an improvement, even for the subject of the experiment himself, over methods long established. Perhaps the *dictum* in the Colorado case with reference to "ordinary" doctors, might help out, should an innovator in the case of an "old" disease, presenting nothing but old and well-known combinations of symptoms, get into legal difficulties by reason of his experimentation.[134]

Other matters coming under the head of negligence, or failure actually to use and employ the reasonable skill and knowledge which the law requires a physician to possess, may thus be stated briefly: A physician is liable for giving improper directions and for failure to give proper ones. He is also liable for failure to call counsel in proper cases. He is just as truly liable for an improper opinion (if damages ensue therefrom) as he is in the case of actual treatment given. He is bound to use pure and proper drugs and aseptic instruments, and to write correct prescriptions. A physician is liable for the malpractice of his partner, though he himself had nothing to do with the case. He is also responsible for the acts of a nurse, if the nurse was acting according to his instructions; and, further, even in other instances, if the nurse was placed in charge of the case by the physician in question who thus by implication warranted her skill and carefulness. A physician is not, however, liable for the acts of a nurse in a public institution in which the physician himself has no direct control over the nurses. A physician is not responsible for the malpractice of a physician in whose charge he leaves a case provided the two are in independent practice (*i. e.,* not in partnership) or of a specialist in independent practice to whom the case has been referred by him.

Sometimes the patient himself is negligent, and, under certain circumstances, this "contributory negligence," as it is called, is a complete defense against a claim for malpractice. However, if the acts of the patient did not produce the injury, but merely aggravated it, they are not a complete defense, but may be shown only "in mitigation of dam-

[134]The leading case on this subject is the Colorado case above mentioned, Jackson v. Burnham. Here the plaintiff had had severe phimosis, and the defendant, instead of slitting up the prepuce, had applied to the penis a flaxseed-meal poultice. Gangrene ensued, together with extensive sloughing, and it became necessary to amputate "his penis wholly from the body." The district court gave judgment to the plaintiff. This judgment was reversed by the Court of Appeals, but sustained by the court of last resort (Supreme Court). Here, however, the innovation was clearly not founded on things already known or on a definite and well-formed theory of benefit to accrue to the subject of the experiment himself.

ages"—*i. e.*, to diminish the amount of the judgment. An important principle is that, if the injury produced by the patient's own negligence cannot be separated from that produced by the negligence of the physician, the patient cannot recover damages.

Some of the commonest forms of contributory negligence consist in (a) failure to follow the physician's directions, (b) not giving to the physician full information with respect to the case, (c) the simultaneous employment by the patient or his friends of other treatment in connection with that of the regular physician.[135]

4. The fourth duty of the physician is, in cases of doubt to use his best judgment. This is a difficult rule to understand, because its meaning is indefinite. Nevertheless, the rule exists, and is exceedingly important. The conception is that a physician, though possessed of a reasonable degree of learning and skill and though exercising care in its application, is now and then confronted by peculiar conditions in which he must use his own individual judgment instead of relying on the common stock of knowledge. Whether, in such conditions, it is actually incumbent on the physician to experiment, is a question which, so far as I have been able to ascertain, has never been decided. Probably, should the question arise, it would be decided in the negative. However, it is likely that an actual case or two will do the utmost possible service in the way of making clear this very difficult rule.

In a rather early case, West v. Martin,[136] the defendant was sued for unskilfullness in the setting of the plaintiff's leg. The defendant, among other matters, pleaded "mere error of judgment." But said Ewing, J., in the Supreme Court: "* * * there may be responsibility where there is no neglect, if the error of judgment be so gross as to be inconsistent with the use of that degree of skill that it is the duty of every surgeon to bring to the treatment of a case according to the standard indicated."

In Dubois v. Decker,[137] the plaintiff, having a crushed foot, was taken to an almshouse, in which institution, some nine or ten days later, the defendant amputated the leg above the ankle joint. "Six or seven days thereafter, gangrene having set in, he again amputated the

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[135]A discussion of this matter would lead us into the never-ending realm of medical folklore. I cannot, however, refrain from mentioning a case in which I was much blamed because, after an entropium operation performed by me, erysipelas supervened. On inquiry, I learned from the patient himself that his mother had twice removed the dressings and applied each time for several hours a poultice of warm cow's dung. I also knew of a case where tetanus set in following the application of road mud to a burn. Without doubt, if proper investigation were made in all cases of malpractice, the matter of folk-medicine would assume a more important aspect in connection with the subject of malpractice defence.

[136]31 Mo. 375 (1861).

[137]130 N. Y. 331 (1891).

leg, this time at the knee-joint. After the second amputation the leg did not properly heal, but became a running sore, and at the time of the trial the bone protruded some three or four inches." The position taken by the plaintiff was that the second amputation had been necessitated, and the deleterious results which followed it had been caused by the delay of nine or ten days in the performance of the first operation. There was expert evidence to show that this was really the case. The defendant alleged "mere error of judgment," stating that he had "waited ten days before operating for the purpose of seeing whether the foot could not be saved, and that a physician and surgeon will not be held liable for mere errors in judgment." But said Justice Haight: "* * * his judgment must be founded upon his intelligence. * * * he should have known the probable consequences that would follow from the crushing of the bones and tissues of the foot."

These two instances serve as well as any that could be selected to show the condition of the law with regard to this very important, yet very indefinite, matter. The cases, unfortunately, relate almost exclusively to the negative side of the question—*i.e.*, as to what does not, rather than to what actually does, constitute the use of one's own best judgment.[138]

Miscellaneous Matters.

An interesting question arises with respect to the medical or surgical malpractice of persons not licensed as physicians. A "graduate optician," for instance, employs the title of "doctor" and "eye specialist" and declares to a patient, that he is a practitioner of medicine and that he can cure the patient's affection by means of a pair of spectacles. The patient is suffering from syphilis of the retina and optic nerve, and, in consequence of the negligence of the graduate optician, he fails to receive the proper kind of medical attention, and his sight is destroyed. Is the optician liable? Again, a druggist treats an injured finger, pretending the while to the patient that he is a physician, and damage ensues as a result of the improper treatment. In all such cases the defendant is liable, precisely as if he were really a physician.[139] A still stronger case is that of Nelson v. Harrington,[140] in which the defend-

[138]We might add, as being somewhat relevant to this rule, the legal principle that a physician who does not feel himself confident to treat a given case, should never, for that reason only, rely upon his judgment in that case, for the "judgment" rule has not for its object the protection of incompetency. In all cases where a physician feels himself to be incompetent, his duty is to recommend his patient to employ another doctor, whether specialist or general practitioner. If, however, the patient, after being thus recommended, is willing and desirous that the first physician continue in charge of his case, then the first physician is not liable (as suggested some distance *supra*) for anything but the very grossest negligence.

[139]Mathei v. Wooley, 69 Ill. App. 655.

[140]72 Wis. 591.

ant was a clairvoyant, whose practice it was to place himself in a kind of trance, and, from that coign of vantage, to diagnose and prescribe for his patients. He had never declared himself to be a physician, but, on the contrary, had often asserted that he had no medical knowledge. Nevertheless, the judgment was against him both at the trial and in the higher court.

However, in this connection it is to be noticed that where the therapeutist or the surgeon does not profess to be a physician and at the same time gives the advice or the service as a friend or neighbor merely, he incurs no liability. The leading case[141] upon this point possesses an especial interest for oculists. The defendant was a midwife, practising in Boston, Mass. She attended the mother of the plaintiff when the plaintiff was born, and, three days later, was shown one of the plaintiff's eyes, which seemed to be inflamed. The defendant declared to the plaintiff's mother that the trouble was "nothing serious, that it resulted from too much light," and she then "directed the witness to darken the room and to dip a linen cloth in water and place it on the child's eye." The room was darkened accordingly, and the application made. Next day the defendant again declared that the trouble was "nothing serious," and that she could cure it, and, this time, she made an application of rose-water. Two days after the first eye presented symptoms of disease, the second eye became affected. However, for two weeks the defendant came in twice daily and applied her washes to the child's eyes. The plaintiff's mother said to the defendant that she was alarmed about the child's eyes, and thought some competent physician should be called in. The defendant, however, replied that she need not be alarmed; that she, the defendant, could cure the disease; that she had cured with her washes several children so afflicted, and mentioned the child of one Mrs. Stevens, whose eyes were much sorer than the plaintiff's, and said she had cured the child's eyes with her washes; that the defendant also told her not to call in a doctor, saying that "the doctors spoiled the eyes of half the children," that "the doctors' washes would burn the child's eyes out"; that she then told her to send for a fresh egg and have it beaten up with sugar, and wash the child's eyes with that," etc. The result was that the child became totally blind, and there was evidence from regular physicians to show that, had other and more powerful remedies been seasonably employed, they would probably have effected a cure. The court, however, said: "The defendant was originally employed only as a midwife. * * * there was no competent evidence that the treatment of diseases of the eyes which might be developed in the child was embraced in the duties which the defendant undertook as midwife * * *. A physician must apply the skill and

[141] Higgins v. McCabe, 126 Mass. 13.

learning which belong to his profession, but a person who, without special qualifications, volunteers to attend the sick, can at most be only required to exercise the skill and diligence usually bestowed by persons of like qualifications, under like circumstances. To hold otherwise would be to charge responsibility in damages upon all who make mistakes in the performance of kindly offices for the sick.[142]

A further miscellaneous matter, and one of much importance, is that, in some states, the defendant in a personal injury suit (to which variety of actions, of course, malpractice suits belong) is wholly devoid of power to oblige the plaintiff to submit to a physical examination for the purpose of determining whether or not his alleged injuries do actually exist, and whether, in case they exist, they are actually of as great extent and severity as the plaintiff has alleged. This would seem to be a very unjust holding, but it is actually the law in Illinois,[143] Texas, Montana, Delaware, and Massachusetts, and also in the courts of the United States. To the contrary, however, hold the courts of Ohio, Kentucky, Georgia, Alabama, Missouri, Kansas, Arkansas, Michigan, Indiana, Wisconsin, Minnesota, Iowa, and Washington. The courts of New York formerly held against the existence of the power, but the decisions of these courts have been overruled by a statute—the only legislation which, so far as I know, has ever been enacted on this extremely important subject in any of the states of the Union.

The courts which hold against the existence of the power, assert that the defendant, in case the plaintiff refuses to submit to a physical examination, may still find a sufficient protection against injustice in the privilege which his lawyer possesses of directing the jury's attention to the fact of the plaintiff's refusal. But, on this point, said Beck, J.:[144] "This position is not correct. The defendant is left to depend upon the inference of the jury, which might or might not have been exercised, instead of having the truth disclosed by direct and positive evidence. The

[142]This case, however much one's sympathies may go out to the child, is nevertheless undoubtedly good sense as well as good law. One cannot, in fact, help recalling, in this connection, the words of Marshall D. Ewell (*Medical Jurisprudence*, p. 291): "If a patient voluntarily employs in one art a man who openly exercises another, his folly has no claim to indulgence. The old Mahommedan case cited by Puffendorf with approbation is very much to the point: A man who had a disorder in his eyes called on a farrier for a remedy, who gave him one commonly used upon his quadrupedal patients. The man lost his sight and brought an action against the farrier for damages, but the judge held that no action would lie, for if the complainant had not himself been an ass he would never have employed a horse-doctor."

[143]I personally know two Illinois physicians (in independent practice) who are considerably out of pocket by reason of the fact that the court which heard their cases refused to compel the plaintiff to submit to an examination of his alleged injuries. The condition of the law on this point ought by all means to be regulated by statute in every State of the Union.

[144]In Schroeder v. C., R. I. & P. Ry., 47 Ia. 375.

law will not require it to depend upon such inference when it can afford the means of producing competent evidence upon the question in issue."[145]

Still another miscellaneous matter relates to the effect which a judgment rendered by a court of law in favor of a physician for his fee, has on the right of the patient, at some later period, to sue the physician for malpractice. It is a well-known fact that not infrequently when a suit is brought by a physician for his fee he is met by a counter-claim for malpractice. Then both matters are litigated together. If the jury decides that the physician has not been guilty of malpractice, then (provided the claim for fees be just and reasonable, not already paid, etc.), the court will give to the physician a judgment for his fees whereas if, on the other hand, the jury holds adversely on the question of the doctor's treatment, then not only does the doctor fail to secure a judgment for his fees, but, generally, he is mulcted in compensatory damages besides. But now suppose the doctor, when he sues for his fees, is not confronted by a claim for malpractice, and that he actually recovers a judgment against the plaintiff for the value of his services, and that, further, at some later date, the patient decides to sue the physician for malpractice. Is the suit for malpractice barred, or is it not?

The answer is that, in the vast majority of jurisdictions, it is, undoubtedly, barred. The great courts of New York, New Jersey, and West Virginia so hold in language clear and unmistakable.[146] Some courts make a distinction, however, between cases in which malpractice was actually pleaded as a defense, and those in which a judgment for the fees was taken by default, or where, though the defendant in the suit did actually appear, he nevertheless defended on some other ground than that of malpractice. Such courts hold that, in the latter two contingencies, the suit for malpractice is not barred. However, even in the great majority of states where the question has never as yet arisen in a court of last resort, the decisions of the courts of New York, New Jersey, and West Virginia, would, by reason of the great persuasive authority of these courts, almost certainly be followed.

A final miscellaneous question relating to the American law of malpractice is: Can a valid judgment ever be rendered against a physician

[145]For an extended discussion of this subject see an article by the present writer, entitled "*May the Plaintiff in a Personal Injury Suit be Compelled to Exhibit His Injuries? If so, Under What Circumstances?*" in the *Michigan Law Review*, Vol. I, Nos. 3 and 4, p. 193 and p. 277, Dec., 1902, and Jan., 1903.

It is interesting to note that the question in hand, though much adjudicated in America, has never arisen for decision in England.

[146]Bellinger v. Craigue, 31 Barb., 534; Gates v. Preston, 41 N. Y. 113; Blair v. Bartlett, 75 N. Y. 150; Dunhan v. Bower, 77 N. Y. 76; Ely v. Wilbur, 49 N. J. L. 685.

for malpractice in the total absence of expert testimony against his manner of treatment? The answer is, Yes, in certain very exceptional circumstances (namely where the existence of malpractice is patent to ordinary comprehension) such a judgment in the trial court would most undoubtedly stand. Just what the necessary circumstances are to enable a court to dispense with expert testimony in a malpractice case, is always a question of fact (not of law) but the following are typical and also actual instances of such circumstances, or rather sets of circumstances. In Moratzky v. Wirth,[147] an accoucheur permitted a portion of the placenta, 2 in. long by 2/3 in. in thickness, to remain in the uterus, by which neglect, as was alleged, the plaintiff suffered from septicemia, resulting in the loss of her leg. Held, that expert testimony was not necessary. In Lewis v. Dwinnell,[148] a physician failed to discover, as was alleged, an extensive perineal rupture. Held, that expert testimony could not be dispensed with. In Richardson v. Carbon Hill Coal Co.,[149] a physician who discovered a fracture of the femur 8 inches from the hip joint, did not discover, as was alleged, a co-existing and very manifest dislocation of the hip. Held, that expert testimony was not necessary. And, in Gedney v. Kingsley,[150] a physician, after the reduction of a Colles' fracture, put on the bandages so tightly that, as was alleged, great ulcers formed and the flesh sloughed off. Held, that expert testimony was not necessary. However, in James v. Crockett,[151] when a physician after repeated and careful examinations and a consultation with a competent fellow practitioner, did not discover a dislocation of the arm, it was held that expert testimony could not be dispensed with.

Legal Considerations Regarding Malpractice in England.

The law of medical and surgical malpractice, is, in England, very much the same as in America. In England, for instance, a physician (if not under obligations by reason of some official position) is never obliged to accept a case, no matter how great may be the urgency of the call or the importunity of the caller. But, a case once accepted, the doctor is under stringent legal obligations to continue in charge of that case—exactly as in America. In England, too, as in this country, the fact of gratuitous treatment does not alter a physician's responsibility for malpractice, nor is a contract with a patient, or with those who stand to him *in loco parentis,* of the very least validity. Such a contract is, as here, "opposed to public policy and therefore void."

The rule which regulates the *quantum* of skill, however, which a physician is supposed to bring to a case is different, in England, from

[147] 67 Minn. 46. [148] 84 Me. 497. [149] 10 Wash. 648.
[150] 16 N. Y. Supp. 792. [151] 34 N. B. 540.

what it is (or rather they are) in America. In America, as we have seen, there exist three rules: (1) That the physician must use such knowledge and skill as prevail in the particular locality in which he practices. (2) Such knowledge and skill as prevail in such localities generally. (3) Such as are possessed and used by highly educated physicians. The second rule, in America, we saw to be by far the most frequently adopted and enforced. Now, in England, the rule is that a physician must possess and use a "reasonable," or "ordinary," degree of knowledge and skill. Not only in the cases but in the text-books and cyclopedias, the words, "reasonable" and "ordinary" occur with great persistency. Thus, in Jones v. Fay (1865) "Any one who attempts to treat a sick person (otherwise than on sudden emergency) will be liable for any lack of such skill as an ordinary qualified medical practitioner possesses." Again, the *"Encyclopedia of the Laws of England"*[152] "A medical practitioner, whether qualified or not, is responsible in a civil action for damages or a criminal prosecution for manslaughter, in case of the lack of reasonable care and skill. In civil actions everything depends on the interpretation of the qualifying words reasonable, and this is for a jury to interpret." The idea of locality, which seems to be the central, the controlling, notion in the American view of medical responsibility, possesses, in English law, absolutely no place whatever.[153] Indeed, in one case, that idea is expressly rejected. Thus, Garrow, B.: "It matters not whether the individual consulted be the President of the College of Physicians or the humblest bone-setter in the village, he ought to bring into the case ordinary skill, care, and diligence."

Lately, however, and unfortunately, there has been developing a tendency on the part of High Court Judges to apply a stricter rule of accountability. This, it seems to me, is a step in the wrong direction undoubtedly, for the proper rule of accountability in a calling in which so much is, from the very nature of things, a matter of individual judgment in the individual case, should be that the practitioner is to be held responsible, not, as in Germany, for the lack of a very high degree of skill, but, as in France, for gross negligence or unskillfulness only. The trouble with the legal view both in England and in America (*a fortiori* in Germany) is that it regards the practice of medicine and surgery as something like, for instance, the industry of cabinet-making. Give to a cabinet-maker the proper materials and the proper tools, and, if he be neither unskillful nor negligent, he will make—and always make

[152]1900-09, Vol. IX, p. 125.

[153]Has not the small geographical area of England, together with the large geographical area of the United States, had much to do with the formation of this distinction?

—for instance, a proper sort of chair. Then, too, the task of making a given kind of chair, for instance, is always and forever the same, and few, if any, competent workmen, would materially disagree as to how that particular variety of chair should be made. In the practice of medicine and surgery, however, the case is very different. In such a calling, a given variety of task is not always and forever the same. In fact, in such a vocation, the task, one is almost tempted to assert, is never twice alike. To a great extent, therefore, in such an occupation, the workman's individual judgment will always be of necessity engaged, and different workmen will, of course, ever be of very different opinions. Only the great settled governing rules and principles should always be adhered to—asepsis, for instance, and the necessity of ligaturing a large-sized wounded artery—and non-adherence to these, *i. e.*, gross unskillfulness or gross negligence, might very properly be chastized by the courts. This, as said already, is the rule in France, and, again, may we not declare *avec raison* that they do really "order these things better in France?"

To hold a medical man responsible for a high degree of skill, is to insist that he shall, under legal sanction, possess a high degree of judgment. This, of itself, would be bad enough, for rules in the realm of judgment have but little application; but where, as in England and America, that high degree of judgment which is legally required, would have to be submitted to the further judgment of twelve often illiterate men, "assisted" by casual (instead of official) expert witnesses, who are sometimes not even licensed physicians, and concerning whose ability to "assist" in the matter in hand, the jury are about as incompetent to decide as they are of determining for themselves the medical questions at issue, then the medical defendant simply plays in a law court a game of chance and with the odds decidedly against him at that.

And, in England, even under such circumstances, the jury might, if they saw, or thought that they saw, occasion, assess *punitive,* as well as *compensatory* damages!

In England, as in America, one who poses as a specialist is responsible for a higher degree of skill than is a general practitioner. I have never been able to find on this point any ophthalmic cases, but it is, undoubtedly, the law as to specialism generally.

In England, too, one who copies an erroneous prescription, as, for example, from a text-book, or a journal article, "adopts the error" "and is liable for any resulting injury."

In England, however, a medical man is not liable for disastrous consequences which ensue upon the following of his "mere friendly street-opinion."

Legal Considerations Regarding Malpractice in France.

The question of malpractice in civil cases, is, of course, never submitted to a jury in France, for the simple reason (as stated in the division on courts and basic legal principles) that, in France, there is never a jury in a civil proceeding. Thus, a civil suit for malpractice can be, and as a fact generally is, in France, conducted very quietly, and, in general, if judgment is not delivered against the physician, the public learns but little about the affair. In a common law country, such as ours, this phase of the French expert system could not, of course, be adopted, for, with us, there must assuredly be juries; but a person cannot help reflecting on the manifest justness and fairness of the French method to physicians who have been improperly accused of malpractice.

In France, moreover, as mentioned already, a physician is responsible only for "clumsy mistake," "gross imprudence or negligence," "ignorance of those things which a man of the profession ought surely to understand." In the language of a text-book,[154] "But, as soon as there arises a possibility of discussion as to the value and efficacy of the treatment which has been employed, upon the propriety of an operation which has been performed, as soon, in other words, as it becomes necessary, in order to determine whether or not a physician has been at fault, to trench upon questions exclusively technical and scientific, *when, in a word, the fault does not appear manifestly,*[155] the courts recognize of themselves their incompetence in this matter."[156] Thus it would seem that, in France, a physician is held responsible for malpractice only in that particular class of cases in which, as we have remarked heretofore, an American court delivers a judgment in the total absence of expert testimony.

In France, however, there exists no law providing that a physician's practice in any particular case be tested by the rules and principles of his own school.[157]

Legal Considerations Regarding Malpractice in Germany.

In Germany, as previously remarked, a physician is responsible if

[154]*Manuel Pratique de Droit Medical*, par Simon-Auteroche, Paris, 1908, p. 186.

[155]The italics do not appear in the original.

[156]Owing no doubt to the existence of this rule, malpractice cases are comparatively rare in France. In fact, I have never been able to find so many as a single instance in which the defendant was an oculist. A number of cases of a general nature can be found collected in Briand et Chaudé, *Manuel de Medecine légale, Paris*, 10th ed., Vol. I, p. 73 ff. Several cases (perhaps more accessible) are collected in Dubrac's *Traité de Jurisprudence Médicale et Pharmaceutique*, Paris, 1893.

[157]The scarcity of such rules in Civil Law countries is owing to the fact that, as stated in an earlier portion of this chapter, in such lands the subject of Evidence does not exist as a well-developed branch of jurisprudence.

he does not exercise "a high degree of skill," "the skill of a thoroughly educated physician."[158] The disadvantages and manifest injustice of such a standard of professional excellence have already been adverted to. However, it is only fair to redirect attention to the fact that, in Germany, a civil suit for malpractice is never tried before a jury, and that all the scientific points involved are investigated, or at least may be investigated, by a corps of medical experts who, as a rule, are really competent for their task. Another disadvantage, though, lies in the fact that the right to bring an action for malpractice outlaws (verjährt) not until three years.

Another peculiarity of the German law of malpractice (though penal, instead of civil, in its nature) is that a physician is legally required to accept a case, if he is so requested, under certain circumstances, by a police-court or any of its representatives. The exact language of the requirement,[159] is as follows: "Whoever in cases of accident or of common danger or necessity is requested by a Police Court or its representatives to afford assistance, and does not comply with the request, although he might so do without material danger to himself, is punishable by a fine not to exceed 150 Marks or by imprisonment." This provision of the Penal Code is held to contemplate professional, as well as non-professional assistance. Being a part of the Penal Code, it is, of course, federal in its nature, *i. e.,* nation-wide in its application.

With regard to experimentation, I can do no better than quote from Strassman:[160] "A procedure, merely because it is new and untried, cannot, only for that reason, be rejected as improper. Were such a principle indeed set in force, there could be no further progress in medicine. One can only require that a new and dangerous plan of treatment should be justified in advance of its employment by much

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[158]The law on this point was, until Jan. 1, 1900, landesgesetzlich (*i. e.,* governed by state law) and hence was different in each of the Bundesstaaten, as is the case in America. On Jan. 1, 1900, however, with the entering into effect of the new "Civil Code," the matter in question passed under the federal law, and, therefore, all the decisions in force (so far as the decisions of courts are possessed of force in Germany) at the present time, are based on the following provision of that code: "Wer vorsätzlich oder fahrlässig das Leben, den Körper, die Gesundheit, das Eigentum oder ein sonstiges Recht eines anderen widerrechtlich verletzt, ist dem anderen zum Ersatze des daraus entstehenden Schadens verpflichtet. Die gleiche Verpflichtung trifft denjenigen welcher gegen ein den Schutz eines anderen bezweckendes Besetz verstösst. Ist nach dem Inhalte des Gesetzes ein Verstoss gegen dieses auch ohne Verschulden möglich, so tritt die Ersatzpflicht nur im Falle des Verschuldens ein."—*Bürgerliches Gesetzbuch,* Sec. 823.

[159]§360, Ziff. 10, Str.-G.-B.

[160]*Lehrbuch der Gerichtlichen Medizin,* Stuttgart, 1895, S. 545. The high degree of authority conceded to text-books by the German courts has already been adverted to.

consideration and reflection, by anatomical conditions, and by experiment on the lower animals. And one should be all the more ready to accept such a justification, the more obscure and atypical the disease." This opinion is characteristically German, insomuch as it clearly admits the necessity for scientific progress by means, at times, of human experimentation, and yet, nevertheless, lays down the only just conditions under which the performance of experiments on human beings could be permitted. It is decidedly in contrast to the rather vague, decidedly unscientific, and often wholly unjust requirements to be found in the law of America.

Legal Considerations Regarding Malpractice in Italy.

Physicians in private practice in Italy are not obliged to accept a case either for examination or for treatment, excepting only in cases of great urgency, when immediate (though not subsequent) aid and assistance is absolutely obligatory on the part of every physician.

Physicians, on the other hand, employed in the official medical sanitary service of the various communes of the Kingdom, are obliged to accept all cases that fall within the scope of their employment. A very extensive and voluminous law[161] has been enacted with regard to these official physicians, regulating their appointments, service, compensation, responsibilities, and participation in the benefits of an elaborate pension system.

A non-official physician, when he has once accepted a case, becomes, of course, responsible for the exercise of diligence and skill while in attendance on such case. His civil liability is regulated not by any special provisions, but by the general laws of the Kingdom, contained in the Civil Code. These laws run as follows:

1151. Any act of a person productive of damage to another, imposes on such person the obligation to indemnify for such damage.

1152. Every person is responsible for the damage he has caused, not only by his act, but also by his negligence or imprudence.

It is, of course, extremely manifest that the law as laid down by article 1151 would, if literally applied, be of so great rigor as absolutely to prohibit the practice of medicine, surgery, and obstetrics in Italy. The courts, however, have, in practice, very much mitigated the severity of the law (as applied to physicians) being, in fact, in this regard, almost, if not quite, as lenient as are the courts of France Thus, for a single example, the Court of Appeal of Bologna has said that "* * * professional error is pardonable in the liberal pursuits when * * * there is no gross negligence or ignorance of clear rules

[161]That of Feb. 25, 1904, entitled *Sanitary Assistance, Hygienic Vigilance, and Hygiene of the Communes of the Kingdom.*

universally recognized and declared.[162] So also Giorgi:[163] "If *errare humanum est* there exists no field in which this sad truth is more applicable than in the exercise of certain offices or professions, which furnish by their very nature a continued theme for controversy and for doubt. The difficulty of tracing out the elements of fact which should constitute the basis of any expert judgment; the variety of systems and of schools; the occurrence of unexpected events; the vast number of the causes which can influence the result in any case, render excusable any such errors as do not depend on the violation of a clear and certain precept or the neglect of treatment which is evidently necessary."

A very peculiar circumstance connected with the matter in question, is that, in Italy, no civil responsibility ensues till after a criminal prosecution has first been brought against the physician and successfully. I know of no such law in any other country.

Another peculiar restriction, if such it may be called, relates to the matter of experimentation. In Italy, in addition to the usual restrictions (preliminary experimentation on the lower animals, some justifiable theory of benefit to accrue to the particular patient who is made the subject of the experiment, etc., etc., as in other countries) it is suggested, in addition, by an eminent Italian legal authority, that the experimenter "before he deduces the innocuousness to man [of the proposed method] from the frog, the rabbit or the dog, ought to have tested the method on himself."[164] This would seem to be a difficult matter indeed to accomplish, in case the experimenter did not happen to possess in his own person a case of the particular malady in question. It would even be extremely difficult for the experimenter to test upon himself the matter of dosage, in case the patient was a child. The restriction might, however, under certain circumstances, very logically be made a condition precedent to the performance of new operations or the administering of new remedies.

In Italy no higher degree of care and skill is legally required of a specialist than of a general practitioner in the same field.

Furthermore, a judgment for malpractice against a physician can be rendered in that country, even in the total absence of expert testimony, provided the existence of malpractice is patent to ordinary apprehension—in other words is not dependent on technical medical or surgical rules and principles.

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[162]Sent. 2 maggio 1902, Filangieri 1902, 862.

[163]Quoted in the *Enciclopedia Giuridica Italiana*, Vol. X, p. 328.

[164]"* * * diversamente il medico risolverebbe i problemi scientifici cimentando la salute e la vita altrui, risparmiando sè stesso, ed allora il malato diventerebbe la bestia da laboratorio, e questa sarebbe seria disonestà professionale." *Enciclopedia Giuridica Italiana*, Vol. X, p. 331.

This completes our discussion of the subject of malpractice with respect to its legal side.[165] We will next take up the

B—SURGICAL CONSIDERATIONS REGARDING MALPRACTICE.

Under this head will be narrated typical and otherwise interesting cases of ophthalmic malpractice which have been the subject of suits either actual or contemplated. Excluded, however, will be all cases which have undergone decision in courts of last resort, for the reason that the most important of such cases[166] have already been discussed under *"Considerations Legal."*

The largest proportion of all the suits or claims for malpractice that ever confront the ophthalmic surgeon arise from strabismus operations.[167] The reason is obvious. A strabismic eye is almost always

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[165]The following extracts from the *Code of Hammurabi, King of Babylon* (about 2250 B. C.) translated by Rob't Francis Harper, Ph. D., would seem to possess especial interest for oculists, beçause without doubt they constitute the oldest extant legislation concerning ophthalmology:

"196—If a man destroy the eye of another man, they shall destroy his eye.

"198—If one destroy the eye of a freeman or break the bone of a freeman, he shall pay one mana of silver.

"199—If one destroy the eye of a man's slave or break a bone of a man's slave, he shall pay one-half his price.

"215—If a physician * * * open an abscess (in the eye) of a man with a bronze lancet and save that man's eye, he shall receive ten shekels of silver (as his fee).

"216—If he be a freeman, he shall receive five shekels.

"218—If a physician * * * open an abscess (in the eye) of a man with a bronze lancet and destroy the man's eye, they shall cut off his fingers.

"220—If he open an abscess (in his eye) with a bronze lancet, and destroy his eye, he shall pay silver to the extent of one-half of his price."

For the rest of this remarkable code, see *The Code of Hammurabi, King of Babylon, by* Robt. Francis Harper, Ph. D., 2d ed., 1904, Chicago, Callaghan & Co.

[166]Except the finely reasoned ophthalmic case of Shelton v. Hacelip (51 So. R. 937, May 7, 1910, Ala.) the report of which appeared too late for insertion in the appropriate division of this chapter—*"Considerations Legal."*

In this case, the plaintiff, a girl of five, was alleged to have lost her eye four years previously, because, when suffering with ulcer of the cornea due to chicken-pox, her physician had, as alleged, prescribed for the corneal affection a solution containing phenol. Judgment for plaintiff below was reversed by the Supreme Court, briefly for the following reasons:

1.—The skill and diligence which the law requires * * * is such as physicians and surgeons in the same general neighborhood, in the same general line of practice, ordinarily have and exercise in a like case." (Note the idea of locality, so characteristic of American Malpractice law, again cropping out, as well as that of the "line of practice.")

2.—"The burden of proof in cases of this character is on the plaintiff."

3.—Insufficient evidence that phenol had been employed.

4.—Plaintiff had waited too long before she brought her suit—four years: a suspicious point in view of all the circumstances.

5.—During those four years plaintiff's parents had continued to employ the defendant in a professional capacity. This, also, was a suspicious circumstance.

[167]So at least according to a collection which I made for many years of newspaper and medical journal clippings which related to malpractice suits, as well as also according to many notes which I made of various cases that

defective in its vision to begin with, and, if the oculist does not observe the precaution to explain and even to demonstrate absolutely beyond cavil the fact of defective vision in each particular case in which he is about to operate, then, after the operation, when the patient, or his relatives for him, are curious about the exact results, the undesirable fact of complete or partial blindness comes out, and the surgeon is blamed for the defective condition of the sight. Already, under the heading of "*Considerations Legal,*" we have seen that several cases of malpractice suits following strabismus operations have even reached the courts of last resort. Here is another instance. An oculist of the highest standing (scientifically at least) did a double internal advancement for a girl of eleven years. He had made a record of the case but had failed to set down the vision of either eye, nor had he directed the parent's attention to the fact that the vision in both of the eyes was decidedly defective. No doubt the operation was correctly performed, but the immediate effect was undeniably an over-correction of six or eight degrees. This instigated the parents of the child to do considerable investigating into the condition of the eyes on their own account (in which proceeding they were ably assisted by a graduate optician) and at last they arrived at the conclusion that the distinguished oculist had ruined the eyes of their child. They then set up a claim for damages against the operator, who, very properly, refused to pay. In search of expert evidence they returned to two eye specialists (practising independently of each other) by whom the child had been examined before they had taken her to the man by whom the operation had been performed. Each of these oculists had, happily, made a complete record of the case, including, of course, the vision of each eye, and very soon the parents were convinced that their claim for damages was unfounded. A laughable feature of the affair was that, when their child had been taken to the last of the three oculists (that one who had done the operation) and by him been examined, he had expressed (after the fashion of some men otherwise sufficiently worthy) several very decidedly unflattering views of the professional attainments and judgment of the two oculists who had been consulted before him. Afterwards, taxed with these ungracious opinions, he, though contritely enough, admitted that he had made them.

I have also known of other instances in which the defective sight of a crossing eye has given rise to malpractice suits, or claims, because, as in the case narrated, the surgeon had neglected, before the operation, to impress the patient, or those responsible for him, with the actual condition of his sight.

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either fell within my personal experience or came to my ears by reliable report.

Deep retraction of the caruncle after a strabismus operation has been, in one instance, the ground of a claim for malpractice. The operation had been performed by a traveling charlatan who was one of the few of his class that I have ever known to be made the subject of a claim, or suit, of this sort.

Next to strabismus operations, as a fertile field for the growing of malpractice suits, comes the various foreign-body cases; foreign bodies in the cornea, foreign bodies in the aqueous, foreign bodies in the iris or the lens, foreign bodies in the vitreous, and, finally, foreign bodies in the posterior wall of the eye and even in the orbital fat. Foreign bodies in the cornea, not infrequently (and even after the most aseptic removal) leave infection of that membrane with consequent ulceration and all the deplorable sequelæ. In such cases, just because the offending substance was perhaps extremely minute, the patient jumps to the conclusion that no such serious consequences would, or could, have followed, had not the treatment been improper.

Small, hard bodies flying with great velocity sometimes perforate the cornea, and then, if the patient is working in comparative darkness, as often happens in the case of miners, the pupil is, of course, rather widely dilated and the tiny projectile will lodge perhaps in the periphery of the lens, and, later, when the surgeon examines the eye, as he usually does, with a very strong light, he contracts the pupil and prevents himself from seeing the offending substance. I was told of a case in which an eye was lost, or was said to have been lost, in this very manner, and which formed the ground for a successful claim for damages.

I had personal knowledge of a case which formed the ground of a claim for damages in which a piece of steel was supposed to have entered an eye very deeply. The attending oculist suggested that the eye be submitted to the X-ray for the purpose, of course, of deciding whether or not there was a foreign body present, and, further, if present, its precise location. The patient, however, refused to have the skiagraph made, first, because of what she regarded as "the very great expense which such a proceeding would necessitate"; and second, because she had heard of people being injured by the action of the Roentgen ray. At the time when the case appeared before the oculist, there was not to be seen a breach of surface anywhere, nor even a trace of any former breach. The aqueous was dark with blood, and so an ophthalmoscopic examination was impossible. The surgeon combatted the inflammation for several days, and then the patient sought another oculist. The second practitioner, after several days of treatment, discovered, whether by skill or by a lucky chance, the offending substance, and removed it with a magnet. Unfortunately, this second oculist per-

mitted to escape him certain remarks which reflected on the skill, or judgment, of the first practitioner, and the result was a claim for damages. The patient brought with her to the first physician's office, her two main witnesses, but these, fortunately for his reputation, refused to stand by the claimant's allegations. The result was that no suit was ever brought.

Ophthalmia neonatorum, too, presents its quota of claims for damages against the attending physician, and, strangely enough, the disgusting and discreditable character of the disease does not suffice in every instance to keep the claim out of court. I knew of a case in which a general practitioner was sued for allowing the disease to occur without the slightest effort to prevent it. He had known at the time of delivery that the mother had recently suffered from gonorrhea, and, in fact, himself had treated her for that disease up almost to the very day of labor. The doctor was given an opportunity to settle for a small sum, and, very wisely, he accepted the opportunity.

Glaucoma, strangely enough, considering the frequency with which the disease is mistaken, and treated for iritis and conjunctivitis, has seldom been the subject of a suit for malpractice. I knew, however, of two cases. One was where a family physician had treated a case of this disease for a very short time by means of atropin and adrenalin, with the result that the patient was very nearly blind when, with considerable indignation, she left him for an oculist. This oculist, though he smoothed the matter over for the family practitioner, nevertheless recommended, as was no doubt his duty, an immediate iridectomy in both eyes. But the operation was indignantly refused. The patient called again on her family practitioner, who strongly stayed her up in her contention that an operation was entirely unnecessary, and who also bade her seek the services of another oculist. The second specialist, being a man of careless speech, said something which aroused the patient's suspicion, and the result was a claim for damages against the family practitioner. The matter was somehow settled.

The second case was where a family practitioner mistaking (as has so often happened, sometimes without the practitioner's fault) glaucoma for iritis, dispatched his patient to a pharmacy with a prescription calling for cocain with atropin. The result was blindness for the patient, and a suit for the doctor. The prescription was on record, and the fact of absolute glaucoma indisputable. The claim was settled out of court by the payment of a small sum.

An oculist of excellent reputation and undoubted ability, being rushed with work, performed a pterygium operation without sufficient consideration of all the factors in the case. It so happened that the patient had dacryocystitis on the same side as that on which the opera-

tion was performed, and the result was a panophthalmitis. A claim followed, which, in some way, was settled out of court.

Now and then a cataract operation gives rise to a suit. I was told by a friend, an oculist, that, after a simple extraction performed by him, he was sued because the operated eye had recovered only half its vision. The doctor, a man of much ability and the very greatest caution, knowing exactly what his rights were, would not scare at all, and the suit was abandoned.

I knew of an oculist who had a case of trachoma in the cicatricial stage, complicated with pannus and numerous corneal ulcers. The patient made an excellent recovery, so at least the oculist thought, but the patient thought differently, or at least professed to do so, and made a claim for damages. The oculist refused to pay the claim, and the patient sued, alleging total blindness. Not long after, and before the case had arisen for trial, the plaintiff fell from a tree in which he was picking cherries, and sustained a fracture of the occipital bone. Shortly afterward he died.

Another illustrative case was this: A miner was struck in the eye by a piece of flying coal. That the injury was severe was shown by the great contusion of the lids and the formation, subsequently, of a deep and angry ulcer on the cornea. In order to cure the ulcer it became necessary to perform a paracentesis of the anterior chamber, and this procedure was carried out with the very greatest caution. The patient got well, and had absolutely perfect vision—for a time at least. In the course of a few weeks, however, a traumatic cataract appeared, and for this the operation was supposed to be to blame. On being informed, however, that the blow inflicted by the coal was itself entirely responsible for this late manifestation, the miner, an exceptionally reasonable man, was altogether satisfied.[168]

Even refraction work is not devoid of the malpractice danger. I had a clipping of a case which related that an oculist, a man of merit and means, had been subjected to a suit because an optician had informed the plaintiff (and afterwards been sustained in his contention by an educated oculist) that one of his eyes had suffered an extensive

[168]Here it may not be amiss to state that the possibility of the formation of a late traumatic cataract should always be explained to patients suffering from ophthalmic trauma, both when the case is taken and again when the patient is discharged. The time consumed is well invested, nor need the patient be affrighted unduly by such an advance explanation, for the matter can be represented (as, in fact, it ought to be) as merely the remotest possibility; and then, should the unexpected happen, the physician is safe.

It is a rather suggestive fact, at least from the doctor's viewpoint, that the number of malpractice suits which a physician is liable to encounter, stands in a direct ratio to his ability to make a judgment "good." In other words, such suits seem to bear relation of some sort to the doctor's financial ability rather than his scientific inability.

detachment of the retina because of a badly fitting lens. In another case, a claim was made against a meritorious oculist because, as was alleged, a badly-fitting pair of lenses had produced a pterygium and "granulated" eyelids. Here is still another case connected with refraction work. A lady, aged 20, complained of headache and rapid ocular fatigue. Test-lenses and ophthalmoscope declared the refraction normal. Into each eye was instilled thrice daily for three days a 1 per cent. solution of atropin. Then the test-lenses and ophthalmoscope revealed four dioptres of hypermetropia. Glasses were prescribed, and she suffered no longer from headache or from ocular fatigue. Nevertheless, she evinced intense dissatisfaction because, her ciliary muscles being now relaxed—as, of course, they ought to be—she was, as she alleged, without her glasses "blind." She admitted that, with her lenses, she saw as well as anyone, and had neither headache nor ocular fatigue, but all this very evident improvement was as dust and ashes beside the over-whelming and heart-rending fact that, without her glasses she was "blind." All the proffered explanations made by the oculist were unheeded, and, indeed, appearances, however unjustly, were much against the doctor. Legal proceedings were discussed, and it was only through the influence of the general practitioner, who had referred the case to the specialist, and who, by the way, was a relative of the plaintiff, that legal action was averted.

I have the record of a number of other cases, but these are not especially illustrative. However, I cannot leave this subject without a bit of moralizing—for which, I trust, the great importance of the subject involved will provide a sufficient excuse. It will have been observed, in nearly all the cases just narrated, that the real, the fundamental, the underlying cause of the suit, or at least of the claim, for damages, was (either by intent or otherwise) another doctor. This fact should give us pause. There is also another fact to be observed in nearly all these cases which constitutes a ground for very serious consideration. And that is this: The defendant, in nearly every instance, was an unusually competent man. I must really dissent from an opinion quite recently expressed by an able lawyer in an American surgical system,[169] which runs thus: "On the other hand, the earnest, diligent, well-read, scientific surgeon, who has a library and reads his journals, who uses instruments of precision, who observes approved methods; the "good," "reliable" surgeon, who knows how to reduce dislocations, adjust fractures, tie arteries and treat wounds, to supervise the use of anesthetics, and to prescribe or conduct the after-treatment, who, after a careful examination, uses his best judgment and skill

[169] Hampton L. Carson, in *Keen's Surgery*, 1909, Vol. V, p. 1180.

in operating, who is exacting as to prior assent, and who instructs nurse and patient as to conduct, while not immune, has little to dread in the courts." This, no doubt, is the strictly legal (also, perhaps, the strictly public and general) view of the matter. But doctors, to whom the subject of medical and surgical merit and demerit is not a sealed, but an open book, are perfectly aware that there could hardly exist a greater mistake than that expressed in the opinion above-quoted. Quacks, as a mere matter of absolute truth, are very seldom sued. On the other hand, the greatest surgeons in the country, subject as they are to continual jealousy, and receiving, as they do, many of the hardest and most inveterate cases, as well as a very high proportion of the most dangerous, are almost continually "in hot water." An excellent ophthalmic surgeon of my acquaintance has been sued, or threatened with suit, no less than seventeen times. And, though no judgment was ever rendered against him, the worry has hurt him and aged him vastly more than all his work. Moreover, in nearly every instance the cause of his trouble was either the malice or the thoughtlessness of a fellow practitioner. The surgeon I have in mind was probably not really to blame in any single instance. And equally good men have not been quite so fortunate as he in the outcome of their suits. All this sad state of affairs with regard to medical and surgical malpractice could easily be different. In the first place, the French standard of responsibility should be adopted everywhere. The physician should be held accountable only for violations of clearly established principles—in a word, for gross negligence or gross lack of skill. Furthermore, expert evidence, in all these cases, should be really expert. Then, too—and this perhaps is the most important matter—every physician who examines a patient that has been to another doctor, should be cautious in every word that he utters. Or, rather, he should be more than merely negatively cautious, he should be positively kind. He should do, in short, exactly as he would be done by. If every physician would only observe this rule—the golden rule in a professional aspect—he would never discover an occasion to regret it, whether he practised in America, in England, in Germany, France, or Italy, or, indeed, in the remotest portions of the earth.

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PART III.

CHAPTER I.

THE DEVELOPMENT OF OPERATIVE SKILL ON THE PART OF THE SURGEON.

By ALBERT E. BULSON, JR., B. S., M. D., Fort Wayne, Ind.

Natural Aptitude for a Surgical Career and Its Development by Training and Experience—Anatomy and Physiology of the Eye Acquired from Text Books, Supplemented by Dissections and Study of the Eye in the Living—The Effect of Health, Temperament and Habits on the Operator—Tobacco, Alcohol and Other Stimulants—Nervousness and Tremulousness During Operations—Time of Day for Operating—Operations on Animals' Eyes—The Use of the Mask—Ambidexterity—Operating Sitting or Standing—The Adjustable Operating Table—Operating With the Fingers—Manner of Holding Instruments—Support of the Hand—Conduct of Visitors and Assistants in Operating Room—Drilling the Patient in His Duties—The Duties of the Surgeon When Acting as an Assistant—Arrangement of Instruments and Dressings—Management of the Eyelids During Ophthalmic Operations—Fixation of the Globe and Arrest of Hemorrhage—Post Surgical Attention.

No field of operative work requires more qualifications on the part of the surgeon than ophthalmic operations. We may say, all other things being equal, that the one who has a special aptitude for and love of the work may be more successful than one who has no such natural tendencies, but, on the other hand, there are some natural qualifications which must be developed and others which must be acquired by any person who achieves the highest success as an ophthalmic operator.

A Knowledge of the Anatomy and Physiology of the Eye Indispensable.

To be a thorough surgeon, it is necessary, above everything else, to know well the organ on which one operates. A comprehensive knowledge of the anatomy and physiology of the eye is therefore indispensable, and without it the appearance and function of the eye are subject to serious and unnecessary impairment through the un-

skilled operative attention of an unqualified surgeon. The requisite knowledge of the anatomy and physiology of the eye cannot be acquired wholly through the perusal of text-books, but must be sought as well, in the study of the organ itself. This education is not complete until it includes thorough and painstaking dissections of the eye in the cadaver, and repeated observation and study of the normal eye in the living. It should also be supplemented by experimental study of animals' eyes and such vivisection as will aid in a better understanding of the various functions of the eye.

Aside from a thorough knowledge of the anatomy and physiology of the eye the skilled ophthalmic operator should possess suppleness of movement, delicacy of touch, quickness of perception and good judgment. These may be inherent qualifications, but they may be developed and improved by training and experience, and are affected by certain conditions and circumstances which must be considered in the development of an accomplished operator.

Care of the Surgeon's Health.

The condition of the surgeon's health may have an important bearing upon his operative success. No man who has an organic or functional affection of the nervous system should attempt ophthalmic surgery, and in fact any disease or condition which weakens the vitality and lowers the nervous tone has its detrimental effect upon the ophthalmic operator. For essentially similar reasons one who has been crippled in the fingers or eye, or deformed, or function impaired from arthritis deformans, rheumatism, or from any other cause is not fitted for the best type of operative work. Good health and a sound body are essential to the success of the ophthalmic operator, and anything which detracts from this necessary condition impairs the chances of success. Thus the practice of some noted operators to avoid engaging in pastimes or occupations which will strain the muscles of the arms or bruise or scratch the fingers, or roughen the skin, and by so doing impair the muscular action and sensitiveness of touch so necessary in a skillful operator, is worthy of adoption by those who appreciate the value of physical fitness. It should be remembered, however, that appropriate gymnastics and exercises of any kind not violent, fortify the health, physical and moral, and augment the courage.

The Operator's Dietary.

Care in diet also has its beneficial effect in keeping the health and temperament at its best. No one whose temperament is marred by a diseased stomach due to injudicious eating or drinking can expect to do the best by a patient requiring the highest form of delicate skill, and no person whose nerve tone is lowered by the use of stimulants

or narcotics is fitted to do the intricate surgery which an eye may require.

The Operator's Eyesight.

Good eyesight is absolutely essential to success as an ophthalmic operator, and one who is not emmetropic should wear the proper lenses to correct his error of refraction. It is also essential that the field of operation should be well illumined either by natural or artificial light.

Tremulousness and Nervousness.

Nervousness may be present in the best of operators, but it should be avoided by suitable training and habits lest the patient suffer from the effects of such a deplorable condition. Landolt says,[1] "one need not tell us that he has seen good operators tremble. They were perhaps great oculists but certainly not perfect operators. Or, if they had been formerly, they had lost that quality with age.

Trembling may have other causes than senility. Very often it is of nervous origin. A certain restlessness and inquietude comes over some surgeons as soon as they are summoned to operate upon a patient, be he awake, asleep or even dead. Generally an active imagination plays an important part by bringing to the mind of the operator all the dangers that can possibly present themselves during and after operation. Sometimes it is not so much interest for the patient as ambition—the fear to excite the criticism of those around—which deprives the surgeon of the necessary composure. The poor unfortunate then finds himself in a predicament: the more he longs to shine the more he trembles, and the more he becomes demoralized."

Tobacco, Alcohol and other Stimulants.

Tobacco, alcohol, tea and coffee, often have power to influence in a most deplorable manner the hand of the operator.

Alcohol is especially apt to disturb the digestive tract and nervous system, while tobacco and strong coffee or tea, particularly if indulged in immediately preceding operative work, frequently produces a nervousness or inquietude of the surgeon which is detrimental to the best type of surgical work. Sobriety is therefore indispensable to the ophthalmic operator who desires to attain the highest degree of success.

Effect of Work on the Operator.

The amount and kind of rest taken by the operator may have its effect upon the result of operative work. Long hours in the office,

[1]Opening lecture of the course on Ocular Surgery, given at the School of Practice of the Faculty of Medicine, Paris; *Gaillard's Medical Journal*, August, 1886.

followed by long hours in social diversion and the consequent loss of sleep may seriously alter what otherwise would be a steady hand. The old adage, "all work and no play make Jack a dull boy," may in a measure be applied to the ophthalmic surgeon, for long periods of work without rest or recreation have a tendency to destroy the composure of mind, steadiness of movement and cool judgment required of one who is called upon to operate upon an organ that is not only delicate and whose movements are so varied and multiple, but whose function may be destroyed so quickly by a false action which in any other branch of surgery would be considered insignificant.

Weakness of the Arm.

But often the uncertainty of the hand is due simply to weakness of the arm. If the latter has not the force to sustain itself for quite a while immobile in one position it begins to tremble, and its movements, hardly perceptible at the shoulder, augment in a most dangerous manner at the extremities of the fingers. This condition may be overcome by judicious corporeal exercise. In fact, all which tends to fortify the health, physical and moral—all that which renders more vigorous the arm and augments the courage—can only profit the surgeon.

The Time of Day for Operative Work.

The selection of the best time for performing ophthalmic operations should be considered from the standpoint of the operator as well as the patient. Most men operate with steadier hand and better judgment early in the morning when fresh from a night's repose and muscles not tired nor nerves unstrung from the labors and vexations of a day's routine work. But the patient should also be considered, and oftentimes it is a matter of necessity to operate promptly, no matter what time of day. In the matter of cataract extraction it has been held by many experienced operators that the operation should be performed late in the afternoon or early in the evening, and for the reason that the smarting or pain which follows the operation is over at about the time the patient would naturally go to sleep, and a night's sleep with its attending quiet may give the wound a chance to close. If operated in the morning the patient may be nervous and restless throughout the day, and the wound does not have a chance to close until later, thus adding to the dangers of complication.

If especially delicate or intricate operations are to be performed during the latter part of the day or in the evening, it is advisable that the surgeon have a short period of rest immediately preceding his task, with the view of attaining composure of mind and steadiness of movement.

Dissections and Study of the Human Eye.

To be a thorough ophthalmic surgeon it is necessary, above everything else, to know well the anatomy and physiology of the eye. This is possible only as a result of study of the best text-books on the subject, careful and painstaking dissection of the human eye in the cadaver, and study of the normal healthy eye in the living.

Dissections on the cadaver should be made with a view to determining not only the relationship of various parts but the readiness with which the eyeball is affected by operative procedures. Whenever possible the various ophthalmic operations should be performed upon the cadaver, always remembering that the resistance of the eye in the cadaver is somewhat different from that in the living human being.

Bajardi[2] has recently published a *stereoscopic atlas* in which the double pictures show very well the various steps in the *operation for senile cataract, discission, iridectomy,* etc. For the beginner this ought to be of valuable assistance and is recommended to those surgeons who desire to obtain as faithful a representation of the principal operations on the eyeball, as can be had apart from their actual performance on the human subject.

Operations on Animal Eyes.

For acquiring operative technique nothing is better than operations on animals' eyes. For the various operations requiring opening of the globe pigs' eyes may be used, and they offer the advantage of being nearest the size and appearance of the human eye. Bullocks' eyes show the relationship of various parts on a larger scale, and for that very reason are not as suitable as the pig's eye. Another disadvantage of the bullock's eye is that it is too large for the instruments ordinarily used for ophthalmic operations, and in the acquiring of technique for ophthalmic operations it is necessary that the instruments and material correspond as nearly as possible to conditions in actual work. What has been said concerning bullocks' eyes applies equally to sheep's eyes, which also are larger than the human eye.

Pigs' eyes are readily obtained and they should be taken from the animal soon after being killed or before any change has taken place. If the cornea has become opaque or clouded as a result of scalding or too long exposure to the air after the animal has been killed the eye is practically useless for operative work. If it is intended that the eyes shall be used within a few hours they can be kept in plain water until so used, in order to preserve their life-like appearance. If, however, the eyes are to be used later they should be pre-

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[2]Bajardi. *Atlas Stéréoscopique de Chirurgie Oculaire.* Baillière, Paris, 1911.

served in a one-tenth of one per cent. solution of formaldehyde, in which solution they will remain quite unchanged four or five days. If the preserving solution is made stronger it hardens the eyes so that they are unfit for operative work. But when preserved the tissues undergo certain changes which materially alter their resistance, and hence it is always better to use the eyes when fresh, and this is particularly true when practising the more delicate and intricate ophthalmic operations.

The pig's eye is particularly adapted to the work of acquiring op-

Fig. 18.
Vienna Mask.

erative skill for the performance of all operations requiring opening of the eyeball, such as cataract extraction, iridectomy, discission, etc. For operations upon the eyelids the cadaver should be used.

The Vienna Mask.

Several ingenious means of holding pig's eyes for operations have been suggested but probably the best is the Vienna mask (see Fig. 18), which is a hard rubber mould of the human head, with openings for the eyes, into which is inserted by a spring and catch the serrated clamp (see Fig. 20) firmly holding the pig's eye so that it gives much of the appearance and relationship to surroundings that

would be present in the human eye. By an ingenious arrangement the eye can be fastened tightly or loosely, and the mask is usually arranged so that it can be placed in any position, imitating the position of the head of the human. Most of the other masks in the market, including the *papier maché* phantom faces, (see Fig. 19) are either good or poor imitations of the Vienna mask. For training the hand and following out the steps of various ophthalmic operations nothing excels operative work upon pigs' eyes in the Vienna mask.

The Home Made Mask.

For those who do not have access to a Vienna mask or do not care to purchase one, a cheap and very efficient mask may be prepared according to plans suggested by Veasey[3] which consist in gluing a

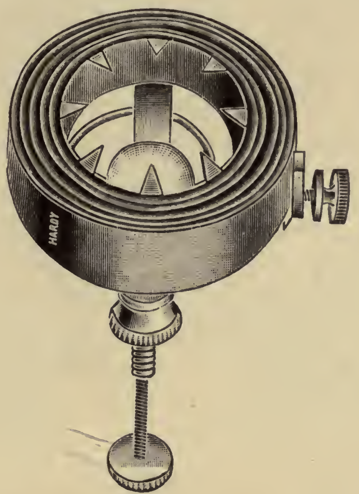

Fig. 19.
Eye Clamp for Vienna Mask.

large, square piece of cork, about one-half or one inch thick, on the lid of a cigar box. The eye is fastened to the cork with tacks in the manner shown in the illustration, (see Fig. 21) and the lid of the cigar box can be raised or lowered to secure any angle desired.

Fixing the Eye in the Mask.

In placing the pig's eye in the mask it is advisable to place the round end upward, inasmuch as one diameter of the eye is considerably longer than the other. This aids in the making of proper corneal sections, as the iris is not so apt to fall in front of the knife.

[3]A Home-made Eye Mask for Practicing Operations on Animals' eyes. *System of Diseases of the Eye, Ear, Nose and Throat*, by de Schweinitz and Randall, p. 613.

A portion of the muscles and conjunctiva should remain on the eyeball to give something for firmer support of the clips which hold the eye in the mask. If the home-made mask is used, a considerable portion of the muscles and conjunctiva will prove of advantage in giving a firm anchorage for the tacks which hold the eyeball on the cork.

The Teaching of Operations on Animals' Eyes.

In operating upon animals' eyes it should be the practice to simulate in every particular all the methods employed in operations upon

Fig. 20.
The Phantom Face.

the human eye, in order to form correct habits and acquire proper technique. The position of the operator and the eye to be operated, the manner of holding the instruments, and the care and disposition of the instruments, dressings and solutions should be given consideration. The position and manner of fixing the eyeball with the fixation forceps, and the amount of pressure to be exerted should be matters of routine. The position of the knife and the position and extent of the incision should also be practised with as much care as though the eye in a living human were being operated upon, and at the conclusion of the operation proper attention should be given to the toilet

of the eye with a view to becoming accustomed to and familiar with the routine procedures of ophthalmic surgery. It is even advisable to invoke the services of an assistant in order to approach as nearly as possible the conditions present at an actual ophthalmic operation.

Ophthalmic Operations on Live Animals' Eyes.

Another valuable way of acquiring technique is to perform the various ophthalmic operations upon the living animal, preferably the rabbit. Large rabbits should be selected, and while many of the operations may be performed under cocaine anesthesia, while the rabbit is securely fastened to prevent movement, it is generally better to use general anesthesia.

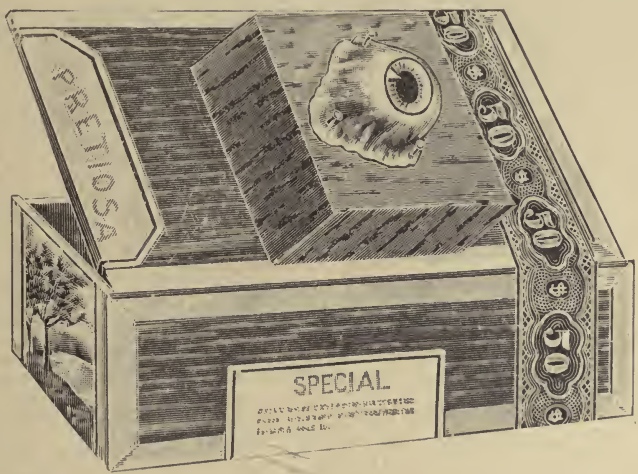

Fig. 21.
Home Made Cigar Box Mask (Veasey.)

Aside from operations which require opening of the eyeball, such as cataract extraction, the eyes of animals, particularly rabbits, are adapted to operations upon the muscles. Thus tenotomies and advancements may be practised with great profit to one who contemplates doing such work upon the human eye.

Ambidexterity.

Operations upon pigs' eyes in the mask, and upon live rabbits' eyes, may also serve to assist the operator in acquiring ambidexterity. Seldom, however, will an operator acquire the same skill for the left hand that he possesses in the right, and the advantages of ambidexterity have usually been greatly over-rated. The right-handed operator will always realize that when it comes to certainty, quickness and delicacy of action his right hand is the more reliable, no matter

how much training he may give the left, and it is a duty he owes to himself and to the patient to operate in a manner which holds out the best hope of success under any circumstances which may arise.

It may be true that the person who has been trained from childhood to use one hand as much as the other may learn to operate as well with one hand as the other, but this will not hold good with the average person who has been single-handed up to the time that his operative experience begins. To him the best results under all conditions will come from the hand that is used to the most exacting work, and whose natural function has been increased by appropriate training. It sounds very well for an operator to say that he makes his corneal section in cataract extraction with the right hand when operating upon the right eye, and with the left hand when operating upon the left eye, and the practice may look well to an audience, but the operators are exceedingly few in number who can use one hand as well as the other, and it is a sacrifice of some of the chances for the highest type of success when the operator fails to use the hand which he knows is the one with which he can do best under any and all conditions.

Many operators are apparently ambidextrous and operate successfully and skillfully with the left hand, but it may be seriously questioned if such operators in an emergency could be depended upon to do as expert work with the left hand as the right, and one never knows when an emergency may arise which will tax to the utmost the suppleness, promptness and delicacy of action sometimes required of an operator, and it is then that it is the height of absurdity to claim that the left hand can be depended upon to the same extent as the right, which from birth has been trained to do all the exacting work.

Ophthalmic surgery demands a delicacy, a surety of the hand and a dexterity of the fingers extraordinary.

Operators should remember that the patient's interests should be served, and no practice which is known to be attended with unnecessary risk to the eye should be followed, and particularly when it has as its principal reason that of convenience and appearance only.

To Operate Sitting not Commendable.

Many ophthalmic surgeons operate sitting, but the position is not commendable as it tends to restrain the movements of the operator. The greatest liberty of action and the utmost independence of movement are necessary to operate well and meet all emergencies. For these reasons one should operate standing, the patient lying on a table whose height brings the patient's eyes on a level or slightly below the level of the operator's elbows when the arms are hanging downward.

The Adjustable Operating Table.

Nothing is so detrimental to an operator's suppleness of movement and delicacy of touch as a strained position such as required to bend over the patient or reach up to him. If the operating table is not an adjustable one, or if the practice followed by many surgeons when extracting cataract of operating upon the patient in the headless bed which he is to occupy, is to be the one of choice, then some

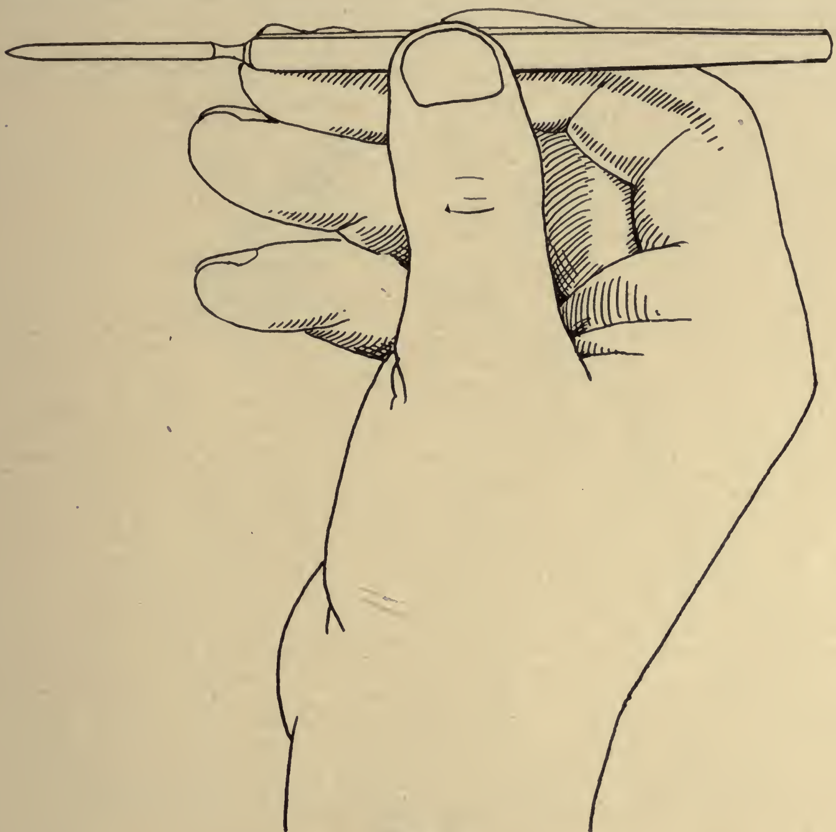

Fig. 22.

A.—Correct Way to Hold the Linear Knife, with the Ends of the Fingers and Handling it with the Forward and Backward Movement of the Fingers.

mechanical means of elevating the table or bed to the proper height should be adopted. A simple means of accomplishing this is to have four blocks six inches square and of the right height, which may be placed under the four legs of the table or bed. Depressions in the upper ends of the blocks will serve as receptacles for the casters or ends of the table or bed legs and prevent movement.

A very satisfactory operating table, particularly for cataract op-

erations when it is desired that the patient be not disturbed after the operation, is the single headless hospital bed with adjustable legs. By means of a tongue and groove and suitable set screws or clamps the legs of the bed may be lowered or raised to any height desired. One end of such a bed may be made higher than the other if occasion demands such a position.

Operate with the Fingers.

In operating, the arms should be free at the side of the body.

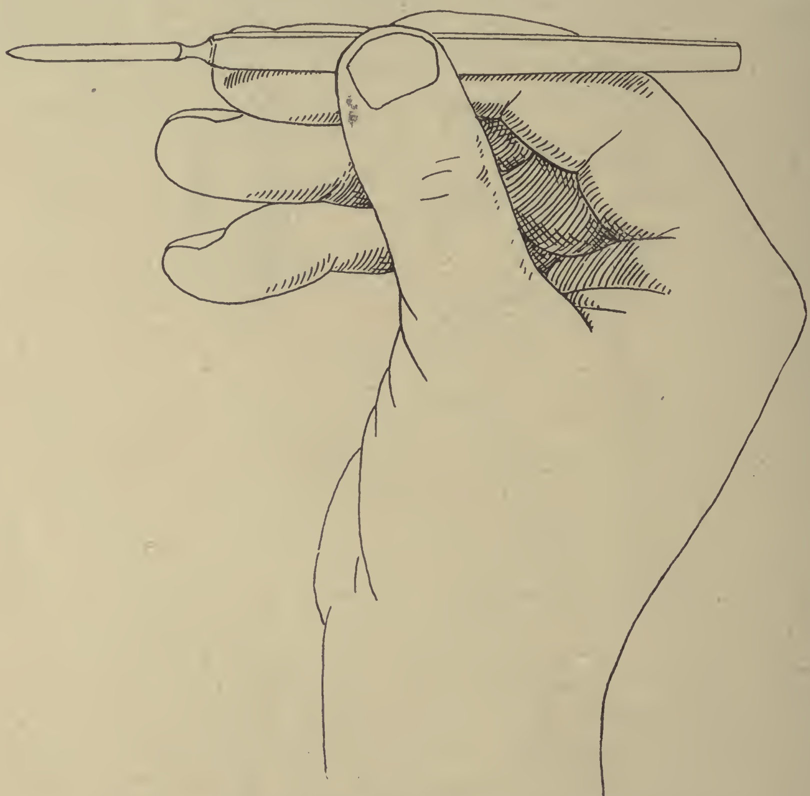

Fig. 23.

B.—Correct Way to Hold the Lin ear Knife, with the Ends of the Fingers. The Knife has been Slightly Thrust Forward by the Movement of the Fingers. (Landolt).

The hand should be independent of the arm and not attached to a rigid wrist which will cause the least motion of the shoulder to be transmitted to the fingers. If the hand be only suspended from the arm, the latter will maintain it in the desired position without communicating to it a shock or any trembling, and above all, allow it all the liberty of rotation. The accomplished ophthalmic operator should

not have recourse to those movements which proceed from the wrist except for varying the position of the hand, for ocular operations proper should be performed only with the fingers. It is the digital execution which makes the operator in ophthalmology. Our tiny sections require, for the very small excursions of the instrument, a radius which scarcely passes two phalanges. On the other hand, the organ we engage is so delicate, so mobile, and it calls for such nicety, such promptness, such harmony of movement, that he who allows partici-

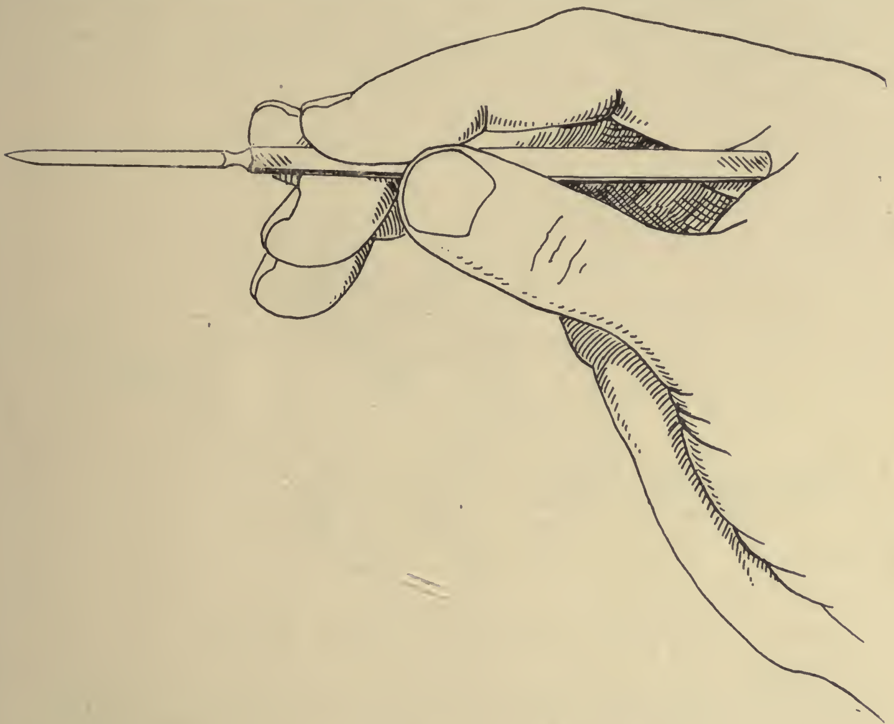

Fig. 24.
Incorrect Way of Holding the Linear Knife (Landolt).

pation of wrist or elbow faces the risk of sacrificing an eye even while attempting a simple keratotomy.

Manner of Holding Instruments.

Concerning the holding of instruments, it should be a fundamental rule to hold instruments in the manner which permits of the greatest and most rapid variation of their direction. Instruments with handles, such as knives, should be held much the same as one would a pencil.

The handles of knives and many other cutting instruments for eye surgery are rectangular in shape, for the purpose of permitting the operator to hold the instrument more securely, and to determine more accurately the direction of the blade or point. It prevents involuntary rotations, at the same time permitting the operator to turn the instrument at will.

The handles of knives and similar instruments should be grasped with the pulps of the fingers only—those of the thumb, the index and

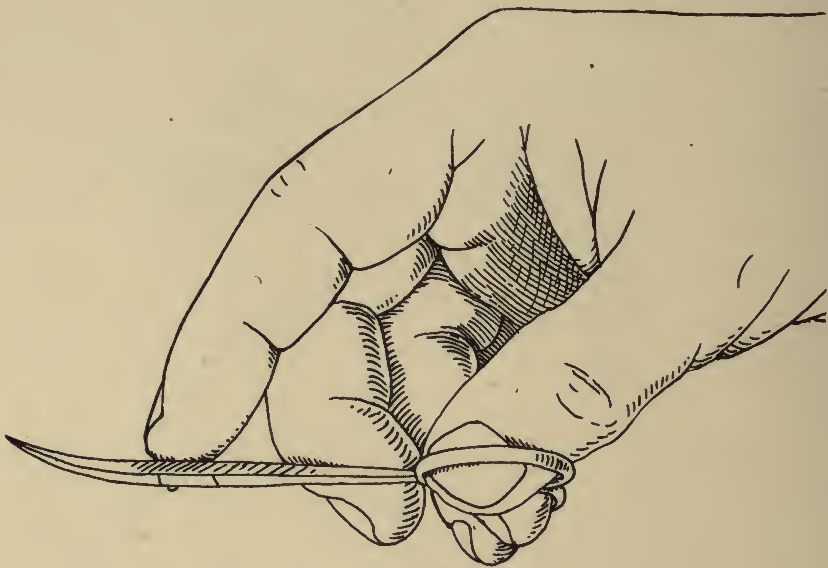

Fig. 25.
Correct Way of Holding the Scissors (Landolt).

the medius. The instruments should be held lightly, and execution should be by simple elongation and retraction of the fingers, without the participation of the hand. The position of the fingers should be such that the extremity of the medius is at the place where the shank joins the handle, so that the instrument may receive the greatest liberty of motion without detracting from the surety of its management. The further the point is removed from the fingers the less surety of action obtained.

In the use of scissors, the thumb is placed into one of the loops, and the ring finger into the other loop, though hardly as far as the articulation of the last phalanx. The bulb of the middle finger rests on the shank of the loop occupied by the third finger, and the index finger is applied at the cross of the scissors. In operating the scissors, the hand must be independent of the arm.

Forceps should be held by the pulps of three fingers only. The thumb should be placed in the center of the shank on one side, the index on the upper half and the medius on the lower half of the opposite shank. The upper extremity of the forceps should never rest on the phalanges of the index, still less be taken into the hand. By holding the forceps as suggested we obtain all the force necessary, and we may impart to its jaws all desired motion.

It is permissible and even commendable to apply the tip of the little finger to a part adjoining the eye to be operated upon. This is not for the purpose of steadying the hand, but of being able to keep in

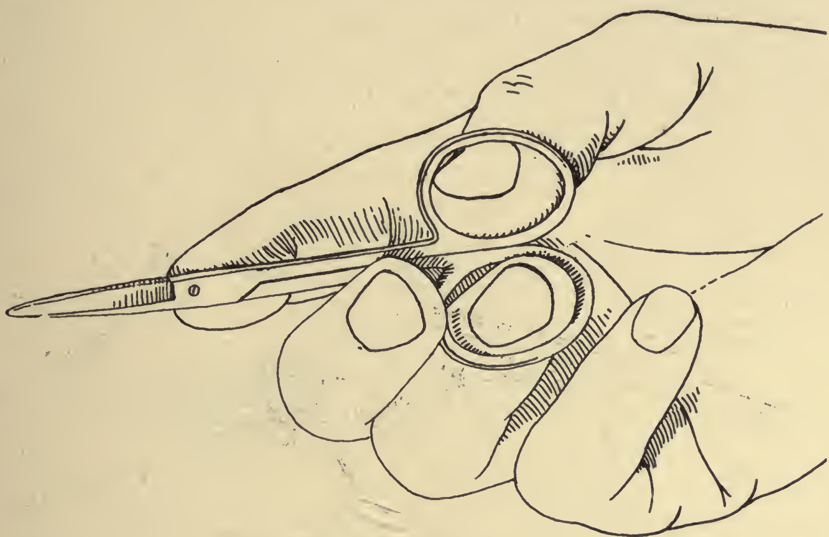

Fig. 26.
Correct Way of Holding the Scissors (Landolt).

touch with the patient and thus warned of any movements that he may execute with the head.

The accompanying figures from Landolt's well-known brochure (see Guilford's chapter) well illustrate the proper and improper manipulation of the ordinary ophthalmic instruments.

Conduct of Visitors and Assistants in the Operating Room.

It not infrequently happens that an operator may persist for years in pursuing a false technique and ignoring the most elementary values of practice because he has had no training during the early part of his career. Text-books have paid scant attention to the manner of acquiring operative technique, and consequently one might regard the subject of minor importance; yet no one better than the experienced operator knows how vital it is to successful surgery. It is

with a hope of attracting the attention of beginners to some of the idioms of ophthalmic surgery that the following suggestions are offered.

As the patient about to be operated on is generally under a local anesthetic only, a discreet silence should be observed, not only by visitors and such friends as have been admitted to the operating room, but by the assistants themselves. The operator only is allowed to speak (especially to the patient), and everyone in the room should absolutely, minutely and silently obey his orders, expressed and understood. The less whispering there is among spectators the better it is for the operator and patient. There is nothing more annoying and distracting to both these principals, and hardly any act more impolite

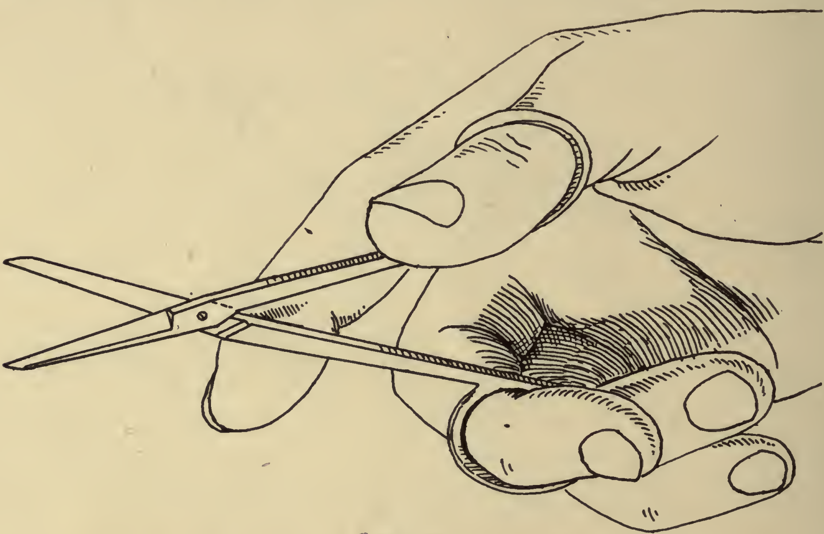

Fig. 27.
Incorrect Manner of Holding and Handling the Scissors (Landolt).

than a muttered conversation carried on about the operating-table during the solution of a serious surgical problem requiring the fullest attention and mental concentration of two persons so vitally interested in the result. This regulation is made entirely in the interests of the patient and is not intended for the glorification of the chief surgeon.

Drilling the Patient in his Duties.

It is always well to remind the patient that he is expected to aid the operator and then drill him in his duties. It is not desirable to explain the steps of the operation to him but the exact character of the assistance expected of him should be clearly set forth. He must not speak during the operation except to ask a question or two that

may seem important or for such directions as he regards as essential. Preliminary exercise in the manner of opening and closing the lids, of looking up, down, in or out, and, if he happens to be very deaf, signals to indicate these movements should be agreed upon beforehand and the patient drilled in them.

While care and tact should be employed in dealing with aged, nervous or ignorant people, they should be warned to keep as quiet as possible, to follow directions implicitly and not to squeeze the lids together, to move the head or to touch the field of operation with the hands. The patient should not, during the operation, hold his breath, nor should he contract the muscles of his lids, face or neck. It is not a bad plan to request nervous or stupid patients to keep the mouth slightly open and breathe through it during the ordeal. If this plan be followed the difficulties just named are generally avoided. It is advisable not to talk to the patient about the operation any more than

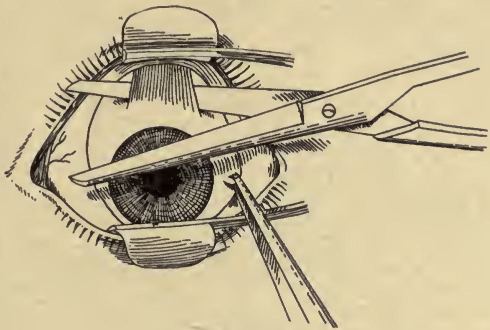

Fig. 28.
Incorrect Way of Using the Scissors (Landolt).

is absolutely necessary, and nothing should be said that will have a tendency to discourage him or make him unduly anxious about the ultimate result.

The Ophthalmic Surgeon as Assistant at Operations.

The assistant, who may in all respects be as experienced and as expert as his principal, should thoroughly acquaint himself with the intent of the approaching operation, should consider its possible complications and should see that all necessary solutions, instruments and appliances are ready at hand, in good condition and sterilized. He should confer with the operator and endeavor to learn just what the latter expects of him. He should follow the operator's lead and give advice only when called upon. He ought not to place his body, hands or head in the way of the operator more than is absolutely necessary; he ought to have each instrument ready in advance of the

operator's actual need and, above all, see that they are not mislaid during the operation. It is a good plan to have the instruments placed in a pan (filled or not with a sterile fluid) and not on a table, as they are more easily kept in order. Knives or other instruments having a delicate cutting edge which the slightest injury will impair, may be laid in racks. When the operator is finished with a certain instrument it should at once be laid in a particular part of the recep-

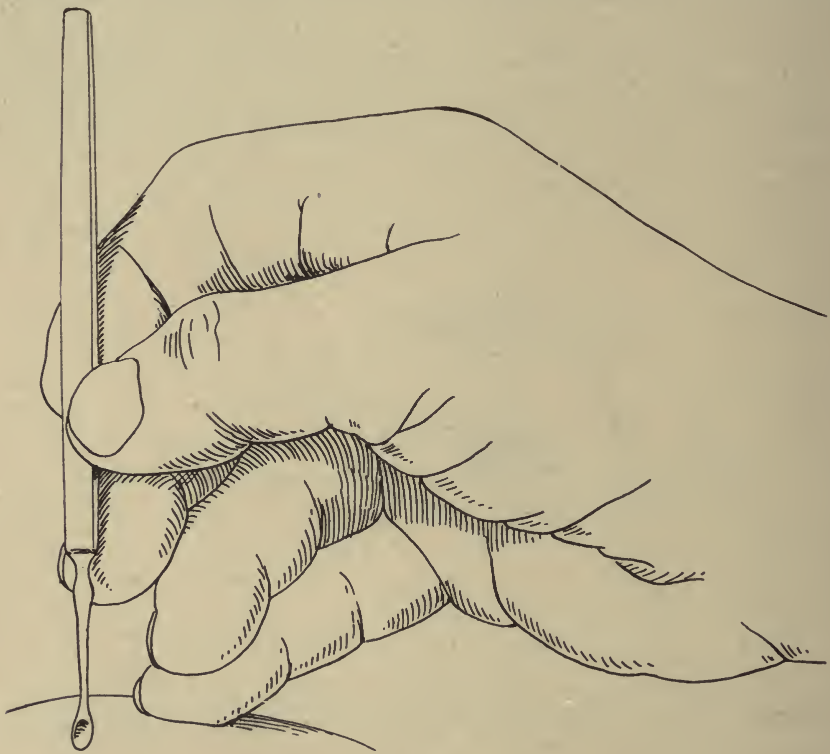

Fig. 29.
Correct Way of Holding the Spatula, Spoon or Curette.

tacle. There is nothing more disconcerting to the operator than to be obliged to pause at a critical stage of an operation while the principal assistant, nurses and, perhaps, bystanders join in a hunt for a knife or scissors that is playing hide-and-seek among the dressings and towels on the operating table. Even if the forgetful operator throws an instrument down instead of handing it to his assistant the latter should at once rescue it and return it to the instrument pan.

If there be more than one assistant each should attend strictly to his particular duties and never, unless requested by the operator, undertake the work of another. When dealing with very nervous pa-

tients it frequently is advisable, if not necessary, for a second assistant to support the patient's head during the operation, by placing the hands on each side of the patient's face. This not only steadies the head of the patient, so necessary for the success of the operation, but has a tendency to calm his nervousness.

Management of the Eyelids During Ophthalmic Operations—Blepharostats

The opening and closing of the lids may be governed during an

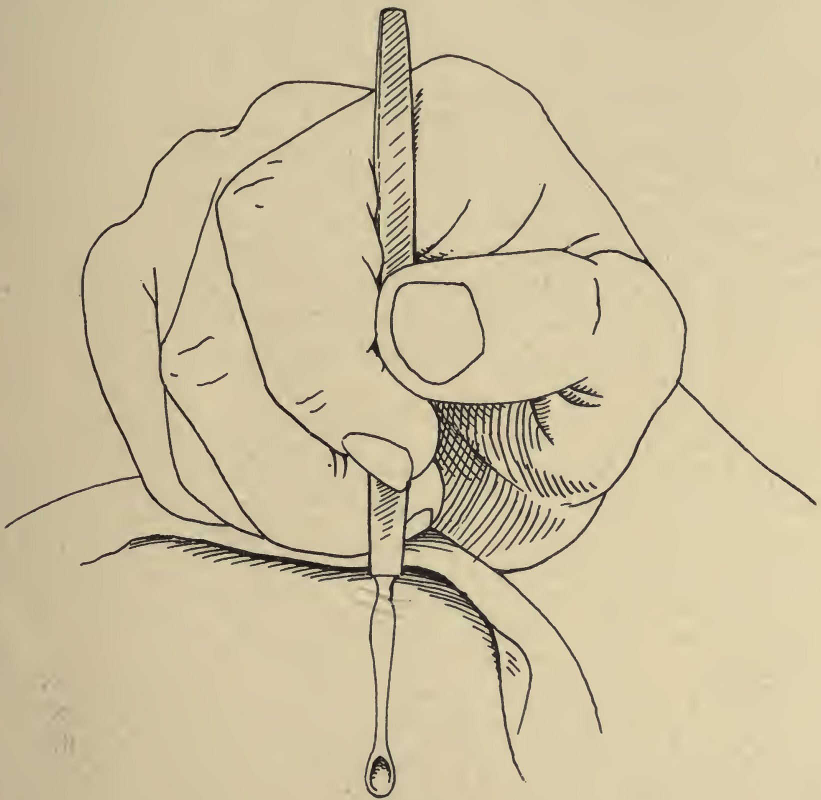

Fig. 30.
Incorrect Way of Holding the Spatula, Spoon or Curette.

operation either by the fingers of the assistant or operator, or by various instruments such as the speculum, or the lid elevator.

There are many advantages connected with the use of the fingers. They irritate the patient less than the speculum and permit of rapid and frequent closure of the lids at critical moments; as, for example, should the patient lose control of himself and violently press the lids together the presence of a speculum is embarrassing and adds to the danger of damaging the eye. Also in passing from one stage of the

operation to another it is desirable to close the lids gently but quickly, and that is best accomplished in the absence of lid instruments.

The repeated opening and closing of the lids is desirable to prevent the drying effects of cocain on the anterior epithelium of the cornea—a condition as undesirable during an operation as it is objectionable from the standpoint of possible infection after it.

The effective employment of the fingers instead of instruments involves, of course, a practiced assistant. He should exercise just the correct amount of "pull" upon the eyebrow in elevating the upper lid, and upon the skin of the lower margin of the orbit in drawing down the lower lid. Above all, *he should never press upon the eyeball.*

The use of the thumb and fingers by the assistant is particularly indicated in short operations, where prompt opening and closing of the lids are needed; also in operations attended by two assistants or where a second one is not required, because control of the lids is the only act the assistant can be called upon to perform; it will occupy all his time and attention and he will not be able to render any further aid, such as sponging, handing out instruments, using the irrigator, etc. An example is in the ordinary extraction of senile cataract.

If the eye is deeply set in the orbit the upper lid cannot be sufficiently retracted to clear the field of operation without dragging forward the outer canthal tissues. The latter stand in the way of the operator, and the situation is rendered still more difficult by the finger or thumb of the assistant on the eyebrow so that cutting instruments or forceps are not easily entered at the upper limbus corneæ. The second assistant may draw the external angle of the lids outward, but a third person at the head of the patient generally adds one more obstruction. On the whole, such cases are best dealt with by the aid of a speculum.

Quite a few operators employ a combination of these methods; a speculum is employed during the first act; (iridectomy, cataract extraction); it is then removed and the assistant's fingers perform the office until the completion of the operation. This plan covers that part of the procedure in which the use of the fingers is most valuable.

It is very important that the lids should be placed under control in a certain definite manner. Having carefully dried the skin over and about the orbit the patient is directed to close the eye as in sleep. If the assistant stands at the left side of his patient and is about to raise the upper lid, he smoothly covers his thumb or forefinger with gauze; or, he will find a gauze finger-stall, tied with tapes about the wrist, a more effective device. In this way the slipping of the controlling digit on the lid, damp from the irrigating solution, or from perspiration or other secretion, is prevented.

The assistant lays ball of finger or thumb over the middle of the palpebral fissure so that its tip covers the lower lid. He then slowly, and without undue pressure, draws the lid upwards so that when the lid edge corresponds with the upper orbital margin the tip exactly corresponds with the lid margin. From that time on until he releases his finger-control he should exert mild pressure of the lid upon the margin of the orbit. He should under no circumstances allow the finger to touch or press on the eyeball, and he should hold the fingers and hand flat on the head of the patient so that they are least in the way of the operator.

The lower lid is drawn down and kept in position with the left hand in the same way as the upper lid is retracted.

Generally both lids are opened, the upper one first, but in operations that involve wide incisions at the upper limbus it is better, after these are made, always to withdraw the lower lid first so as to avoid contact of the interior palpebral margin with the upper edge of the wound. If this rule is not remembered the lid edge may be pushed into the open wound, an accident sometimes followed by immediately serious consequences or, occasionally, by late infection of the incision.

The Speculum.

Although the speculum enables one to dispense with at least one assistant, in that they hold the lids apart, yet they do not prevent a nervous or an unruly patient from exerting pressure upon the eyeball; indeed, the limbs of some instruments actually provide a sort of fulcrum on which the orbicularis may act and compress the globe even more effectually than if no speculum had been introduced. It is for this reason a good plan, during cataract extraction or other procedure in which the eyeball is opened, to remove the speculum after the corneal or sclero-corneal incision has been made and have the lids separated by the aid of an assistant's fingers.

Another plan, especially valuable in prominent or projecting eyeballs, is to have the assistant raise the speculum (thus pushing the lids forward and away from the globe) on the least suspicion that the patient is about to squeeze his lids together. In these cases the powerful anterior fibers of the orbicularis palpebrarum are able to compress with increased force the unresisting eyeball. For small and deeply placed eyes this danger is not so great and, as we have already seen, for such the speculum is, perhaps, to be preferred to the assistant's fingers.

To introduce the speculum into the right eye correctly the upper lid is drawn upward with the left forefinger of the operator who stands behind the patient in the same manner as described in the use

of the fingers as a means of separating the lids, the patient being meanwhile directed to look down. This act raises the margin of the upper lid from the globe, when the upper limb of the closed or partially-closed speculum is gently inserted parallel to the palpebral margin, between lid and eyeball, and pushed toward the upper sulcus. The forefinger is now removed, the patient directed to look down, the lower lid drawn downwards, the lower arm of the speculum inserted in the same fashion as the upper, the forefinger again removed—and the instrument is in place. The patient is now asked to open the eyes widely, the spring with which most specula are provided causes the arms to separate and follow the lids. When the lids are sufficiently open the speculum is locked, generally by means of a screw. If the patient does not open the eyes widely enough, the arms of the speculum are further spread by means of the finger. Some operators prefer a speculum without a lock or stop of any sort, as they would

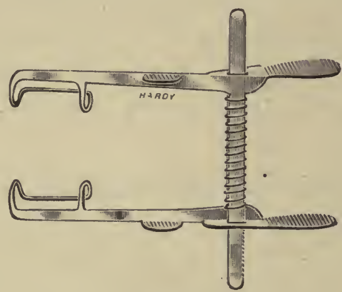

Fig. 31.
Mellinger's Eye Speculum.

rather risk the patient's squeezing his lids than the loss of the valuable instant of time required in an emergency to unscrew or undo the mechanism necessary to unlock the speculum. For this and other reasons Czermak[4] prefers Mellinger's speculum. This instrument is of the simplest construction, has no lock, screw or other complicated mechanism, but is held open automatically by the pressure of the lids. All its parts are smooth, readily cleaned, easily taken apart, and so fashioned that the branches do not irritate or invite the patient to squeeze up his lids. They have, however, one serious failing; should the patient persist in tightly shutting his lids, it is almost impossible to remove the instrument;—a very serious matter in case of actual or threatened loss of vitreous, for instance.

Czermak *(loco cit.)* suggests a remedy for this defect which, he believes, is due to the construction of the wire loop that enfolds the lid margins. Since this modification he has also been able to dis-

[4]Czermak. *Augenärztliche Operationen*, I, p. 5, 2nd Edition.

pense with the spiral spring that separates the arms as well as the screw for locking them.

The Retractor or Lid Elevator.

A third method of separating and fixing the lids is by means of the retractor or lid elevator. This valuable instrument is generally found of several sizes in the form originally invented by Desmarres. The smaller sizes are particularly intended for use in operations on the cornea and at the limbus. When in place the flat surface of the palpebral end entirely covers the lid margins and the cilia. However, the handle is rather in the way when fixation forceps and other instruments, (especially keratomes), are to be used on the upper aspect of the globe, unless the patient is unusually quiet and obedient. This objection is almost insurmountable when the eye lies deeply in the socket. The objection may be overcome, however, by constructing the lid elevator so that its handle will be rather long and curved backward to lie close to and conform to the head, as is the case with the Fisher lid elevator.

To introduce the lid retractor the upper lid is raised with the

Fig. 32.
Fisher's Lid Elevator.

forefinger in the manner previously described, the rounded end is inserted between the eyeball and the palpebral margin and gently pushed to the upper fornix. The handle is then pulled firmly forward, so as to draw the lid away from the globe without pressing the sharp edge of the rounded plate too much against the upper sulcus. The assistant should not, on the one hand, press the lid too strongly against the margin of the orbit because that is painful, nor should he drag too much on the periphery of the lid lest the latter slip off the end of the retractor and fall against the eyeball at a critical stage of the operation. If he will remember to draw as much of the lid as possible away from as much of the globe as he can without hurting the patient he cannot go far wrong. It will then be noticed how completely and painlessly he can control the movements and how impossible it is, even in prominent eyes, for the nervous or stupid patient to squeeze the lids against the eyeball.

Fixing the Eyeball During Operations.

By far the commonest instrument for this purpose is the well-

known fixation forceps provided with three or four teeth. The latter should not be, as they often are, provided with sharp points or cutting edges, as they lacerate the tissues. The purpose of the forceps is to grasp the soft parts and not to cut them. Elschnig[5] recommends a straight forceps provided with three teeth, one blade with one tooth, the other with two, set at an angle of 45 degrees. When the blades are placed about two mm. apart near the sclerocorneal junction, gently pressed against the globe and then closed, the episcleral tissues are caught in the teeth without damaging them, yet fixing the eye securely.

The fixation forceps are generally placed close to the limbus because the conjunctiva in that situation is less movable than elsewhere. If the operator should tear the mucous membrane and still desire fixation, the underlying scleral tissue, or even the tendon of a straight muscle can be grasped, but the latter method is a painful one and to be avoided as much as possible. Apart from ignorance or carelessness this accident is most likely to happen when the patient is under a general anesthetic and the operator attempts to drag in the opposite

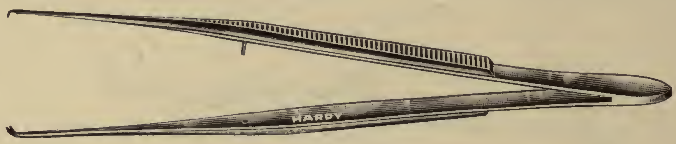

Fig. 33.
Elschnig's Straight Forceps.

direction an eyeball that has rotated beyond his reach. It is not to be forgotten that gentleness, quite as much as firmness, is a part of ophthalmic operations.

Generally the teeth of the fixation forceps are placed on the opposite and corresponding part of the globe to the point of puncture. In the corneal incision of cataract extraction with an upper flap the area of fixation is best chosen a few mm. below the meridian of the counter-puncture so that the knife, as it cuts its way out, may not come in contact with the forceps.

The assistant should particularly bear in mind while holding the fixation forceps that neither pressure nor dragging movements should be made upon the eyeball. The purpose of the forceps is to steady or fix the globe as securely as possible without injury to its tissues or discomfort to the patient. If it is necessary to rotate the globe the patient should be requested to look in the required direction while the forceps, although held in their closed condition, should simply follow

[5]Czermak and Elschnig, *Augenärztliche Operationen*, 2nd Edition, Vol. I, p. 6.

the globar movement. If the patient be under a general anesthetic, or if for any other reason he cannot look in the required direction, the eyeball may be rotated, not pulled or pushed, the forceps being always held at the same tangent to the globe. When it is desirable to fix the eyeball with greater security than usual, as for example in trephining the cornea, two forceps are employed, one at each end of the same corneal meridian. These are held in each hand of the same assistant. Double fixation forceps have been devised for this purpose, but in general these are not very satisfactory, because it is difficult to secure equal fixation with the two sides of the forceps, and there is more apt to be unnecessary and perhaps dangerous traction on one side or the other if there is a sudden and unexpected movement of the eyeball.

There is, as a rule, not only no need for a catch, or lock in the fixation forceps, but they are generally a nuisance if not a positive danger, because too much valuable time is wasted in applying and releasing them.

If there is a particular objection to making even the slightest wound in the conjunctiva and no special reason for securing fixation of the globe, as in tattooing the cornea, a blunt forceps may be used—one provided with serrated ivory, celluloid or hard-rubber terminals.

In some cases, as in enucleation of the globe, operations on the vitreous, etc., where forceps are inconvenient, a needle and thread are passed through the conjunctival and episcleral tissues at the limbus and brought out about a cm. from the point of entrance. The ends of the suture, which may be about 23 cm. long, are held by the assistant who can easily rotate the globe to any desired condition.

The instruments mentioned above will all be found and are pictured in Dr. Guilford's chapter.

Arrest of Hemorrhage.

Although this subject will be treated elsewhere in this work, it may be repeated here that the use of cocain and adrenalin suffices in most operations on the eyeball to prevent or arrest the small amount of bleeding occasioned by surgical intervention. It is a question whether post-operative hemorrhage is lessened by the employment of these and similar local applications; indeed there are reasons for believing that it is increased, but at any rate they usually furnish a bloodless field for a time sufficiently long to allow the steps of the operation to be concluded.

In angiosclerotic subjects or in deep operations about the eyeball more effective agents must be applied. Apart from the use of hemostatic forceps, ligatures, etc., the application of iced pads is valuable. Aseptic gauze soaked in a saline solution—itself in a glass

surrounded by salt and cracked ice—is applied (and changed frequently) to the globar wound or to the closed lids.

Post-Surgical Attention.

The operative technique of the surgeon or his assistant does not end with the operation proper but follows in the after-treatment. Nothing is more discouraging to the operator than to have a faultless operation marred by the clumsy and unskilled manipulation of an assistant or nurse in the bandaging and dressing of the wounded eye. Dressings should be delicately and painstakingly applied, and removed in the same manner. All undue pressure upon the eye should be avoided, and the greatest caution observed in removing dressings immediately covering the eye, lest undue damage be done to the healing process. This is especially important in plastic operations about the lids, in cases of skin-grafting, and in all operations where the eyeball has been opened. If secretions cause the bandage or dressings to adhere they should be softened with sterile solutions until their removal can be accomplished without in the slightest disturbing the wound. Sometimes a pair of dressing forceps is preferable to the fingers in removing dressings, owing to the greater delicacy with which the necessary manipulations can be made.

In wiping away secretion the greatest gentleness should be employed, and especially when removing it from the lid margins and around the eye lashes. If the eye lids are to be opened to expose the eye due care should be exercised to prevent the slightest pressure upon the eyeball. *Many post-operative complications can be traced to careless and rough manipulations of assistants and nurses* who fail to appreciate the fact that the utmost delicacy of touch and precision of movement are necessary in dressing or caring for bandaged eyes if the best success is to be obtained. One false or hurried movement of those to whom the post-operative attention is entrusted may defeat the purposes of the surgeon.

CHAPTER II.

THE PREOPERATIVE TECHNIQUE OF OPHTHALMIC SURGERY.

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Antisepsis and Asepsis—Clinical and Other Preoperative Examinations and Treatment of the Patient—Preparation of the Patient—Preparation of the Operator—Preparation of the Assistants and Nurses—The Position of the Patient, of the Operator, of the Assistants and of the Equipment During Operations—Visitors and Other Spectators—Preparation and Methods of Sterilization of Collyria and Solutions, Sponges and Swabs, Dressings, Sutures, and Instruments—Testing the Sharpness and Competency of Instruments—The Preparation and Disinfection of Rooms for Operations.

Antisepsis and Asepsis Before Ophthalmic Operations.

Under modern methods it is the exception to see anything but healing by so-called "first intention"; but in days not far distant this was seldom observed. On the contrary, injuries were only too often, particularly in institutions for the sick, followed by extensive suppuration, local decay, and the death of the individual. So wonderful are the changes that it is difficult for us to realize now the state of affairs that existed less than half a century ago; but it was not so long ago that Lister, influenced by the bacteriological work of Pasteur, conceived the idea that the terrible conditions observable in surgical wards were due to the contamination of wounds by micro-organisms pervading the air, and that beneficial results would occur if infection of the parts could be prevented. How correct these surmises were, and how remarkable have been the improvements in surgery since the introduction of Lister's methods are fully known even to the layman. It matters little if some of Lister's ideas were not entirely correct; our modern surgical technic has developed uninterruptedly under the eyes of the present generation of practitioners since the announcement of that distinguished surgeon's theories.[1]

Thanks to innumerable workers, nothing in medicine now rests

[1]Lister. Contributions to the Germ theory of Putrefaction. *Tr. Royal Soc., Edin.*, 1863.

upon a more solid basis of fact than the bacterial causation of inflammation; and with this knowledge has come a clearer view of the various channels of infection. We strive at present for the complete disinfection of the field of operation and the prevention of contamination, not only from the air (the possibility and importance of which were over-estimated by Lister) but from every extraneous source of asepsis. These are our ideals; but that we have so far been unable to realize them, and that circumstances and conditions often compel us to fall back upon the original idea of controlling bacterial processes (antisepsis), is only too well known. Especially is this true of ophthalmology where the local anatomical conditions, which will be dealt with more in detail elsewhere in this section, present obstacles in the way of complete asepsis insurmountable by any means that we now have at hand. Still, the goal is apparent; but undoubtedly advance would be more rapid if the spirit of progressiveness in this direction were more pronounced among ophthalmologists. I say this advisedly, because I am persuaded from wide observation that oculists as a class lag behind their confrérés of every other specialty in the matter of surgical cleanliness.

The reasons for this are apparently not far to seek. Many, perhaps most of them, do not have the advantage of that training in a general surgical clinic without which it is very difficult to secure a thorough grounding in this important department of their work. On the other hand, a knowledge of the practical impossibility of completely sterilizing certain parts of the field of operation, and of the relatively great resisting powers which the ocular tissues possess, breeds a laxness that readily passes into actual uncleanliness. Still, the facts of asepsis are so well established and are so often brought to the attention of the surgeon, both as undergraduate and practitioner, that there is no excuse for negligence or for partial measures, which are not only illogical but because of our imperfect knowledge of infection, apt to be dangerous. We should rather, as Czermak and Elschnig[2] point out, accept the favorable local conditions which Nature has provided, not as an excuse for greater laxity, but as a stimulus to achieve a fuller measure of success in our work; and unquestionably the practice of ophthalmology will be most rapidly advanced by a spirit of open-mindedness which speedily adopts every sound procedure indicated by our developing science.

It is not my intention in this chapter to enumerate all the various chemical and physical agencies which surgery employs, or has tried to employ, to control bacteria and their effects; these are more fully and

[2]Czermak and Elschnig. *Die Augenärztlichen Operationen*, Vol. I, p. 47.

more properly treated of elsewhere.[3] My purpose is to describe in detail the various practical measures which are now generally undertaken to prevent infection previous to an ophthalmic operation, and to mention the facts and theories upon which some of them are based.

Preoperative Examination and Treatment of the Patient.

Before considering these matters in detail, however, something must be said of the necessary preliminary examination of the patient; for it is only too well known that at times the greatest surgical skill may be entirely annulled by failure to recognize some baneful local or systemic condition which conscientious forethought might have easily eliminated. In no department of surgery are these sources of infection so well known as in ophthalmology, and today it is only a question of systematically searching to determine with a great deal of certainty their presence or absence.

This part of the subject is conveniently treated under two headings: (1) The *general* examination and treatment of the patient; and (2), the *local* examination and treatment of the patient.

Systemic Examination and Treatment.

The systemic examination, which on general principles should always precede the local, is undertaken for the following reasons: First, to detect conditions that will throw light upon the etiology of the patient's disease; and, second, to exclude disorders that may directly or indirectly complicate his operation and convalescence.

The examination must, it goes without saying, be thorough and searching; but it matters little with which system one begins provided none is omitted. The special points to be brought out under the first heading will vary with the nature of the case; but under the second division there are certain things to which one should as a routine pay particular attention. In taking the anamnesis, inquiries should be made in regard to the patient's behaviour during operations, if he has ever before undergone them; touching his reaction to drugs, especially atropine. Irritation or poisoning from belladonna should be marked on his case report, preferably in red ink as done at "Moorfields," before leaving the hospital. Enquiry as to his general nervous condition should be noted, in view of possible mental derangements following the operation. Where anesthetics are to be given, an examination of the urine, of the heart, and of the mouth for false teeth should under no circumstances be omitted. Cough, as the result of some affection of the respiratory tract, is likely to be troublesome or even dangerous in

[3]For an exhaustive presentation of the subject of disinfection see Gotschlich, Kolle and Wassermann, *Handbuch der Path. Mikroorganismen,* Vol. I, Part I, pp. 179-265.

cases where the eyeball is opened, and should be thoroughly controlled before anything is done in this way. The nose and nasopharynx, especially because of the close relationship of affections of these parts to disease of the lachrymal canal and the patency of this structure, should be carefully explored for adenoids, rhinitis, and the like. If necessary, the digestive system must be put into good order, and the diet and bowels regulated according to the needs of the case.

On the evening preceding an operation under general anesthesia, a purgative of some kind is to be administered, and on the following morning an enema is given sometime before the patient actually goes to the table. Finally, one should seek always to determine to what extent the patient has himself under control; for a great deal of information can be gained by watching his behaviour at the time of putting in drops and the like, and, profiting by these observations, one often has timely warning to take extraordinary precautions during the performance of the operation.

Local Examination and Treatment.

The local examination is undertaken to establish on the one hand the indications for operation, and on the other to exclude as far as possible all sources of infection.

Under the first heading is included more especially the clinical examination proper, which is not to be discussed in this article. The second division embraces particularly a thorough inspection for styes, blepharitis, Meibomian abscesses and other like foci of contamination. All of these, when present, call for thorough eradication by the ordinary remedies and measures.

The skin of the lids gives the same bacteriological findings as the rest of the surface of the body (Gotschlich); one gets almost invariably only staphylococci of low virulence (Terson and Cuénod).[4] Along the margin of the normal lid the same organism is met with, frequently in association with the harmless xerosis bacillus. Blepharitis sicca is comparable to seborrhea sicca and of questionable bacteriological origin; but, in blepharitis ulcerosa, the staphylococcus aureus, generally of a markedly pyogenic nature, is the commonest finding.[5] The impetiginous eczemas and eczema impetigiosa, which not infrequently affects the lids, commonly yield streptococci and are to be treated with great care. From the typical stye one obtains almost exclusively the staphyloccocus aureus (Axenfeld).

We are now fully aware from many investigations, that even an apparently normal conjunctival sac is never entirely free from bacteria,

[4]Terson and Cuénod. *Bactériologie et Parisitologie des Paupières.* Thèse de Paris, 1894.

[5]Axenfeld. *Die Bakteriologie in der Augenheilkunde,* 1907, p. 53.

that, indeed, pathogenic organisms, are often present, still bacteriology has gradually brought us to a point where, with a considerable degree of certainty, we can distinguish between those germs of low virulency, the effects of which are ordinarily successfully controlled by the tissues of the eye, even when wounded, and other bacteria of greater pathogenicity, more commonly found in inflammations of the conjunctiva, which are liable to give rise to destructive inflammations. Today, therefore, no preoperative technique is complete which omits a routine bacteriological examination of the conjunctival sac. While it is true that the data derived are not always entirely sufficient of themselves to justify a definite course of action (and one must often in the end be swayed as much by the clinical appearances as by the bacteriological findings), yet an exact knowledge of the organisms present rounds out our view of the case and aids in determining what is best to be done.

In connection with these investigations a couple of points require special mention. The first is, that one should always begin the examination by making the ordinary cover-glass smears of the secretion, which are quickly prepared, easily stained and examined, and give valuable information in regard to the number and variety of the bacteria present, and the kind and range of culture media it is best to employ for their growth. The second point is, that it is useless to inoculate only the tubes that are commonly found in the laboratory, broth, agar, gelatine, and the like. These will grow many of the bacteria found in the conjunctival sac; but the pathogenic micro-organisms that give the most concern from the point of view of infection require highly nutritious, specialized food for their development (particularly the agars containing blood, serum and hemoglobin), and these should be employed from the outset to obtain satisfactory results.

Of the greatest importance is the determination of *the condition of the lachrymal canal and sac.* The bacteriological investigations of recent years have only served to make more clear what has long been clinically well known, namely, that so great is the danger of infection in cases of dacryocystitis that to open the eyeball in the presence of this condition is to court an almost certain panophthalmitis.

Regarding the bacteriology of the conjunctiva in cases of dacryocystitis Axenfeld *(loco cit.)* writes as follows:

"The unusual prevalence of bacteria in the lachrymal pus in cases of dacryocystitis early received attention at the hands of Leber, Widmark, Sattler and Schmidt-Rimpler. With many of the pure cultures, as well as directly with pus itself, purulent infections of the cornea were produced, corresponding to experiences with the human eye. Schmidt-Rimpler compared inoculations of pus with those of the cultivated cocci, and proved that the lachrymal secretion possesses a very variable degree of infectiousness. * * * In the beginning attention was more especially directed to the staphylococcus and streptococcus; but later it became apparent through the work of Gasparrini, Cuénod, Mazet and Uhthoff and Axenfeld that the pneumococci, which can be demonstrated in large numbers, and in the viru-

lent form in the majority of cases, have first and foremost to be taken into account. * * * If we regard the facts of the matter and consider the bacteriological findings, we see that, in simple catarrhal dacryocystitis, the pneumococcus, either pure or mixed with other bacteria, holds the most important place. Next in frequency are the staphylococci; then perhaps gram-negative bacilli of the influenza group; and finally streptococci and other pyogenic bacteria. Staphylococci are not infrequently associated in small numbers with other germs; but they are very seldom pure or present in such relatively large numbers that they can be regarded as the primary etiological factor."

In trying to obtain evidences of dacryocystitis it is not sufficient to merely apply pressure with the finger over the lachrymal sac as is commonly done; for, as Axenfeld has pointed out, the lachrymal crest may be so developed that it prevents regurgitation taking place even when discharge is present. Moreover, it is now known that an increase in the number of the micro-organisms of the conjunctival sac takes place when even slight obstruction to the flow of tears (which apparently act not so much in a germicidal way as in a purely mechanical manner in reducing the number of organisms present in the eye) is present. Syringing is the only safe way of determining the patency of the canal, and in performing this slight operation, I would emphasize the necessity of producing as little trauma of the canaliculus as possible. The average syringe tip is large, rough, irregular and capable, through tearing of the parts, of originating an inflammation which may be really dangerous.

When obstruction of the lachrymal canal is found (dacryocystitis), the question will arise as to what is best to be done. Few oculists will now dissent from the view that complete extirpation of the sac, performed according to the modern, subperiosteal method, some considerable time before any intraocular operation is undertaken, offers the greatest safeguard against infection. Closing the puncta by cauterization and tying off the canaliculi (Buller) are now generally considered to be inefficient procedures; and certainly no reliance is to be placed on measures destined simply to cleanse the sac and canal.

The bacteriological examinations of Plaut and von Zelewski[6] show that, within a few weeks of a properly performed extirpation, the conjunctiva becomes relatively safe from the point of view of infection, and can be cleansed at will. Axenfeld *(loco cit.)* attributes this diminished virulency to the removal of pre-existing conditions within the sac (temperature and secretions) favorable to the growth of dangerous organisms, especially pneumococci, and to the beneficial action of the tears. The same writer emphasizes the fact that the interval between the excision of the sac and the intraocular operation must not be a fixed one, but must vary according to the clinical and, especially, the

[6]Plaut. Ueber den Keimgehalt der Bindehaut nach der Thränensack-extirpation. *Klin. Monatsbl. f. Augenheilk.*, Bd. 39, 1901, p. 369.

bacteriological findings. Even the best conducted bacteriological examinations will sometimes fail, however, to detect lingering pyogenic bacteria. In one of my own cases of this kind, where the pathologist reported negative findings, infection leading to panophthalmitis occurred through the extreme lower-inner extremity of the wound, which, as is generally the case, was incompletely protected by the conjunctiva. Under these circumstances, conjunctival flaps, previously prepared with scissors, may be employed as an additional precaution against entrance of bacteria to the interior of the globe. When marked changes in the conjunctiva and lids are associated with a dacryocystitis, special treatment directed toward these conditions is, as a rule, required, because the extirpation of the sac will not of itself entirely cure them.[7]

PREPARATION OF THE PATIENT.

It is a common practice to admit patients to the hospital a few days previous to their operation in order that they may become accustomed to their surroundings; but it is a question if this policy is altogether advisable. In the case of public patients there is generally no other course to pursue; but with private patients, where systemic and local examinations can just as well be made at home and in the oculist's office, a wiser practice, in my opinion, is to make the time spent in the ward before the operation as brief as possible. Nervous people, and particularly those of advanced years, are undoubtedly under less strain in their usual surroundings and with those they are accustomed to have about them. When an operation has been decided upon it should be carried out as expeditiously as possible; for the suspense in these cases is very great and may end, as I have seen in more than one instance, in a severe nervous breakdown.

The *first steps in the preparation of the patient* are a warm general bath and a thorough shampooing of the head, which, in hospital patients, should afterwards be washed off with some antiseptic solution, say 1 to 60 carbolic acid. In women, the hair should, after a thorough drying, either be rolled and tightly pinned on the top of the head or plaited and drawn more or less to the side opposite the eye upon which the operation is to be performed. Pediculi, often present in children of the lower classes, are to be thoroughly gotten rid of before the operation by some kind of germicidal remedy, employed either with or without a close cropping of the hair, as they are very difficult to control during the after-treatment of the patient. Care of the teeth and gums forms an obligatory part of the toilet, and a mouth wash[8] is prescribed

[7] Byers. Conjunctival flaps in Ophthalmic Surgery. *Trans. Am. Ophthalm. Soc.*, 1910, p. 398.

[8] The mouth wash generally prescribed in our clinic is made up as fol-

as a routine. Altogether apart from the remedy of obvious pathological conditions in the nose, it is good practice, a few times before operating, to spray the inferior meatus with one of the many alkaline or oleaginous sprays now in common use.

While a good deal of latitude is permissible in the case of private patients, inmates of the public wards should be obliged to wear, following the bath, clean, disinfected garments provided by the hospital. The practice of allowing them to retain their ordinary clothes has now been almost universally discarded as being unhygienic and even dangerous. In addition to night-dresses, women are supplied with wrappers of gingham or similar material, and the men suits of gray homespun or some such stuff.

The Preparation of the Field of Operation.

The patient's hair should, first of all, be confined by a head dress like that pictured in Fig. 34; or a rubber cap of the same shape which

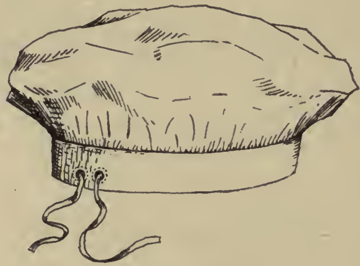

Fig. 34.

Cap for Confining and Protecting the Patient's Hair Before and During Operation.

will prevent the head from becoming wet, may be used. The latter should be kept in different sizes to accomplish this purpose more fully. The nurse now proceeds to the actual preparation of the field of operation. Needless to say she must observe every aseptic precaution as regards herself before undertaking this work.

The eybrows, the lids, and that part of the face which comes within the scope of the proposed operation are first washed with green soap and sterilized water, friction being applied as thoroughly as the parts will permit, with a sterile brush and gauze swabs, for a period of at least five minutes. Following this cleansing, the whole area is rinsed and mopped off with some antiseptic solution, as, for instance, perchloride of mercury or alcohol in proper strengths. In operations upon the globe, as the head and eyebrows are to be covered by sterile lint, it is

lows: Bicarbonate of sodium and borax, of each two and a half drachms; carbolic acid, one drachm; and water to eight ounces. Of this a teaspoonful in a wine glass of water is used at least night and morning.

not obligatory to shave these structures; but in other procedures, when the wound is to actually fall within the parts which they cover, and the technic just outlined is of necessity more rigidly carried out, they must be removed.

The *preparation of the conjunctiva* calls for a few special remarks. Following the discovery that micro-organisms are present even in the apparently normal conjunctival sac, numerous attempts were made to produce disinfection of this part of the eye with a large number of different reagents. Experience soon showed, however, and subsequent investigations proved, that this ideal was unattainable; that germicidal remedies, used in strengths even less than sufficient to have any appreciable effect upon the bacteria present, were followed by conditions which increased rather than diminished the number of micro-organisms; and efforts in this direction were consequently abandoned. Later, it was found that simply flushing the eye with any bland, sterile solution, in imitation of the mechanical action of the tears, produced a higher degree of disinfection than any other procedure. The best practice now is, at the preliminary examination in the ward and again just previous to operating, after everting the lids, to thoroughly irrigate the conjunctival sac with a solution of boric acid, saline solution, or even sterile water, conveniently employed from a glass undine, or a porcelain jar with tube connection and glass nozzle, as pictured in Figures 35 and 36.

An almost equally difficult problem is the *sterilization of the lashes.* That these structures, even in an apparently healthy eye, and especially in cases of marginal blepharitis, carry pathogenic micro-organisms, has been shown by Stroschein,[9] Müller,[10] Holth,[11] von Pflugk,[12] and others.

The success of any method destined for the elimination of this real source of infection depends, as Pflugk points out, upon the power of the reagent employed to remove the bacteria present by cleansing the cilia of those oily secretions by which they are normally covered. His experiments seem to show that on the one hand simple washing of the lids with soap and water is insufficient, and on the other hand that benzine is superior to ether (Sattler),[13] alcohol, and the other fat emulsi-

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[9]Stroschein. Die Aseptik bei Augenoperationen in der Würzburger Universitäts-Augenklinik. *Archiv f. Ophthalm.*, Vol. XXXIX, 1893, p. 256.

[10]Müller. Ueber Cilien in der Vordenkammer und spontane Ausstossung derselben. *Wien. Klin. Woch.*, Vol. VII, 1894, p. 231.

[11]Schiotz. Le traitement de l'oeil avant et après l'opération de la cataracte. XIII. *Cong. Int. de Méd.*, Section d'Oph., Paris, 1901, p. 279.

[12]von Pflugk. Ueber die Vorbereitung des Lidrandes und der Cilien für Bulbusoperationen. *Archiv f. Augenheilk.*. Bd. XLV, 1902, p. 176.

[13]Sattler. Ueber die offene Wundbehandlung bei Operationen am Augapfel, insbesondere bei Staaroperationen. *Bericht der Ophthalm. Gesell.*, 1900, p. 93.

fiers which have been brought forward for this purpose; that, in fact, complete sterilization, which thus obviates the necessity of epilation (Schiotz), or cutting of the lashes (Haab,[14] and others), can be achieved with this substance.

Pflugk's method of sterilizing the lid edges with benzine is, in detail, as follows: After anesthetizing the conjunctiva with a five per cent. solution of cocain, the lids and the surrounding surface are thoroughly cleansed with sterile wool and water, care being taken that water, swabs, and soap are frequently changed. Having rinsed away any residue of soap, the conjunctival sac, and especially the fornices, are lightly mopped out with a cotton-wool swab, rather firmly squeezed out after dipping in salt solution. The parts about the eye are now

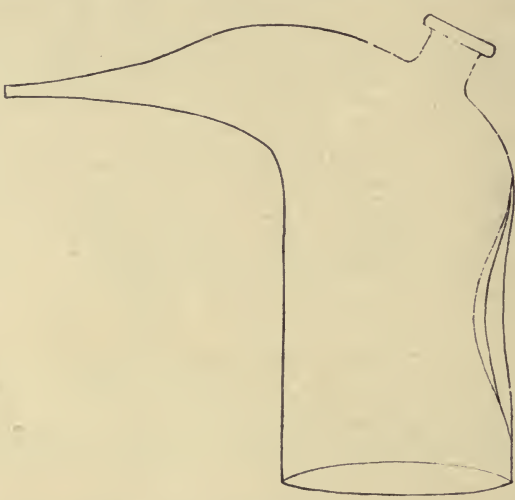

Fig. 35.
Undine for Washing Out the Conjunctival Sac.

covered with a sterile pad, provided, by tearing or cutting, with an aperture just sufficiently large to allow the lashes to present and to expose about one centimeter of the adjacent skin of the lids. The cilia and the lid margin are then energetically rubbed six or eight times with a cotton-wool tampon upon which about twenty drops of benzine have been allowed to fall; and, following this, a swab soaked in salt solution is placed over the lids until they are opened again for the instillation of the anesthetic.

The danger in Pflugk's procedure is, as mentioned by himself, that during the manipulations bacteria may be carried to the lashes from the more or less incompletely sterilized, surrounding parts. For this

[14] Communication to von Pflugk.

reason I would insist upon a more thorough scrubbing of the lids with soap and brush or swab as already outlined. A routine, however, which I believe offers an absolutely safe protection from infection in this way, is to sterilize the lashes in the manner suggested by Pflugk, cut away any particularly prominent lashes at the outer angle which may possibly come in contact with the knife, and then use a speculum similar to Lawford's (see Fig. 37), which is secure, does not encroach on the palpebral aperture and is provided with hollow clamps that completely surround the remaining lashes; or, particularly in nervous cases, broad lid separators are held in position by assistants.

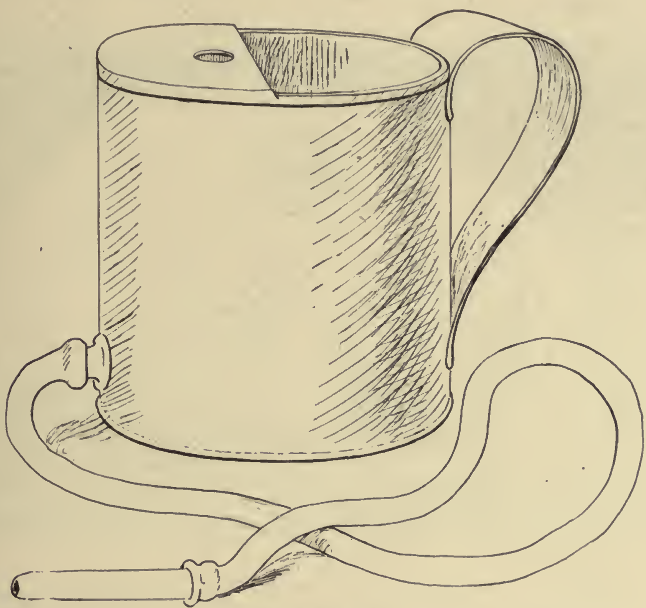

Fig. 36.
Porcelain Jar with Rubber Tube and Glass Nozzle Attachment for Washing Out the Conjunctival Sac.

When the patient is stretched upon the table, the bandage holding the dressing in place is permanently removed; but the eye is only momentarily uncovered for the instillation of drops until everything is ready for the actual operation. The head with the cap still in position is covered in the following manner: An ordinary, sterile, hand-towel is folded upon itself along the whole of one side to a breadth of about four inches. The double band thus made is placed upon the patient's forehead, and carried firmly around either side to the nape of the neck, where it is secured by a safety-pin. The remainder of the towel is now tucked beneath the occiput, where it rests upon the sterilized covering

of the pillow and is securely held by the weight of the patient's head. The body of the patient is covered with a sterile gown or sheet, and another towel is placed over the upper part of the thorax and tightly about the neck, for cleanliness and to prevent the garments beneath from becoming soaked with any of the solutions employed. Finally, when cocainization is complete and everything is in readiness, a gauze pad (see Fig. 37), with a central aperture sufficiently large to allow of the necessary manipulations upon the globe, is placed over the side of the face upon which the operation is to be done; or, more simply, a piece of gauze, in which an opening of the required size is made at the time of the operation, is used for the same purpose. When anesthetics

Fig. 37.
Face-Covering with Aperture Over the Field of Operation and Lawford's Speculum in Position.

are given it is customary to remove the outer garment; and dry underclothes will, of course, be kept ready in case they should be required.

PREPARATION OF THE OPERATOR.

The physical well-being of the ophthalmic surgeon is a matter that often receives less consideration than it deserves. The ophthalmic surgeon especially should be continuously in good training; and this implies not only properly regulated physical exercises, but the moderate use or entire avoidance of those things—tea, coffee, alcohol, tobacco, late hours, prolonged study—which are liable to impair the steadiness of his hand and the tranquility of his nervous system. Most men feel at their best in the morning hours, and for this reason,

other things being equal, it is better to operate in the early part of the day. The forenoon, too, has the advantages of an almost certain supply of good light for those who prefer it to artificial illumination, and of being less trying to patients, especially those who have to take a general anesthetic.

In ophthalmic operations the kind of *dress to be worn by the surgeon* may vary somewhat with the nature of the work to be done. In operations upon the globe, where little or no hemorrhage occurs, a simple, sterile gown will suffice. This should extend well down below the knees, be provided preferably with a high "military" collar, and fasten behind. The sleeves may be short, or (much better) long to fasten tightly about the wrists. In any case, this garment should be donned only after the surgeon's shirt sleeves have been rolled well up out of the way, and his coat and vest (the dirtiness of which may be demonstrated to the entire satisfaction of the most incredulous by a few moments' application of a modern pneumatic cleaner) removed.

In operations about the lids, orbit and lachrymal sac, where the danger of infection is greater and a good deal of hemorrhage is liable to occur, most operators will prefer to clothe themselves in the manner now commonly adopted by general surgeons. A suti (see Fig. 38), consisting of a blouse with short sleeves and a pair of trousers, cleaned but not necessarily sterilized, is put on over the under garments; and in this attire the sterilization of the hands and arms is carried out. When this has been completed, the suit is covered either by a sterilized apron (see Fig. 39) or, completely, by a sterilized gown with short sleeves (see Fig. 40). Much preferable is a gown with long sleeves (see Fig. 41), which fastens tightly about the wrist. If much hemorrhage is expected, it is customary for the operator to still more completely protect himself by a rubber apron interposed between the suit and the gown.

As the ophthalmic surgeon frequently bends over the patient's face, it is quite conceivable that loose hairs, drops of sweat and particles of dust or dandruff may accidently fall from the operator's head into the wound. The possibility of infection in this way may be remote; but, as a skull cap of the ordinary type (see Fig. 39) is easily made from inexpensive material, it is better, if only for the sake of general cleanliness, to add a proper *head dress* to the operator's apparel.

Of more importance is the question of *face masks*. The possibility of contaminating wounds by bacteria expelled from the mouth during the act of speaking, which was first pointed out by Flügge[15] and more particularly emphasized in ophthalmology by Axenfeld[16], has received

[15]Flügge. Ueber Luftinfection. *Zeitschr. f. Hygiene*, Vol. XXV, 1897, p. 179.

[16]Axenfeld. Mundschleier zur Vermeidung der Tröpfcheninfektion

Fig. 38.

Cap and gown that are put on by the surgeon before personal sterilization.

Fig. 39.

Sterile apron that is donned after the "wash up." The surgeon is wearing, also, a cap and a face mask of the type suggested by Czermak.

considerable attention during the past decade. Hotta's[17] experiments seem to show, however, that the danger of infection in this way in ophthalmic operations is very slight, as linear, in opposition to "pocket-like" wounds, are not favorable to the arrest of bacteria and are easily flushed by the tears. Still, in view of the knowledge which we now possess of this subject (Axenfeld has shown that one has to do here particularly with the dangerous pneumococcus) it ought to be obligatory in cataract operations at least, and following colds, and where much teaching is being done, to wear one of the numerous forms of mask now in vogue. See Figures 39, 40 and 41.

Of the various modifications of this appliance, the one brought forward by Czermak (Fig. 39) which consists of a wire framework covered with gauze and held in position by rounded, spectacle-like side-pieces extending behind the ears, is the most comfortable; but it has the disadvantage of being somewhat more difficult to prepare, of being subject to rust, and of being less easily adapted to the several operators who may make use of it. The simple gauze varieties are hotter, and are more liable to cloud the glasses of those who wear spectacles; but they are more readily prepared and sterilized and indiscriminately used. A simple and efficacious way of achieving the desired end is by using two pieces of gauze about a yard long and two feet broad. After folding these upon themselves three or four times, one of them is placed over the nose and mouth in front and tied by a single knot well above the occiput behind. The other, placed across the forehead, is tied behind below the hitch of the first one, which it retains firmly in position.

Repeated bacteriological investigations place emphasis upon *maintaining the hands in good condition.* They should be free from chapping, fissures and the like, even when scrubbed long and thoroughly (five minutes at least, better ten) with sterilized brushes; or, as George Armstrong, Surgeon to the Montreal General Hospital, prefers when the process has to be often repeated, with squares of folded, sterilized gauze. Many operators have now done away entirely with the after use of germicides, and simply rinse the hands in sterile water or some mild antiseptic solution after the mechanical treatment. Rubber gloves, properly prepared, are then drawn on as a final precaution; but an equally large number of surgeons still adhere to a combination of friction and disinfection.

The following regulations, observed in the service of James Bell,

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(Flügge) bei Augenoperationen. *Klin. Monatsbl. f. Augenheilk.*, Vol. XLI, 2, 1903, p. 474.

[17]Hotta. Experimentelle Untersuchungen über die Infektion von Hornhautwunden durch Speichel. *Klin. Monatsbl. f. Augenheilk.*, Bd. XLIII, 2, 1905, p. 237.

Fig. 40.

Surgeon's Wire Cap, Face Mask and Sterile Gown with Short Sleeves.

Fig. 41.

Surgical Attire, which, with the Exception of the Shoes, Meets Every Modern Requirement.

chief of the general surgical clinic, Royal Victoria Hospital, Montreal, illustrate a rigid combination technic of this sort: Bare the arms to above the elbows, and trim the finger nails until the space beneath them is laid entirely free and is thoroughly cleared. Rub the hands and forearms with green soap; scrub them with a nail brush in running water, for five minutes. Devote five minutes to scrubbing the finger nails and fingers (each separately) with brush and green soap in running water. Wash away the soap in running water. Immerse the hands and forearms for one minute in a bath of a saturated, sterile solution of permanganate of potash; then in a sterile solution of sulphurous acid until the permanganate has been entirely decomposed and all color removed; and, finally in a bath of bicloride of mercury (1-2,000) for two minutes. Dry and dust the hands for gloves.

If, after preparation, the hands or forearms come into contact with anything which is not absolutely sterile, the whole of the foregoing cleansing process must be repeated with, perhaps, a shorter period of mechanical cleansing. After aseptic operations the whole of the cleansing process must be repeated before the next operation, but less time may be devoted to mechanical cleansing. After septic operations, at least the whole of the foregoing cleansing process must be repeated; and in bad cases such additional precautions must be taken as are considered necessary by the operating surgeon. In the case of rough, chapped, or infected hands, or any lesion of the skin of the hands or forearms, the operating surgeon must be consulted about the preparation for operation.

In ophthalmic surgery, coverings for the hands can hardly be recommended for the finer operations upon the globe, and indeed they are unnecessary; but in other procedures, like, for instance, evisceration of the orbit, where the work is of a gross character, gloves are quite serviceable. Where, during an ophthalmic operation, it is necessary to take hold of bits of unsterilized apparatus for the purpose of making tests and the like, the mittens shown to me some years ago by Landolt in his clinic in Paris will be found very convenient. These are shaped like the ordinary mitten and are easily made of lint and sterilized. Without fear of contamination the operator can slip his hands in and out of them as they lie upon the table.

PREPARATION OF ASSISTANTS AND NURSES.

Assistants that are actually taking part in the operation *will prepare themselves in exactly the same manner as that described for the operator*. For nurses a few modifications are necessary. Only a gown which completely covers the body (see Fig. 42) will meet the necessary requirements, and some sort of head dress should be worn. That

Fig. 42.
Nurse's Cap and Gown.

pictured in the same illustration is the most comfortable and efficient that I have seen, and can be made according to the following directions:

Take a piece of muslin three-quarters of a yard square and make a hem (A) two inches wide across one end. Round the corners of the other end, and make a small hem all around to meet the wide, straight hem first mentioned. Half an inch below the hem (A) cut a slit six inches long on each side, and make these firm again with another narrow hem. On the lower end of these slits sew a half yard of white tape

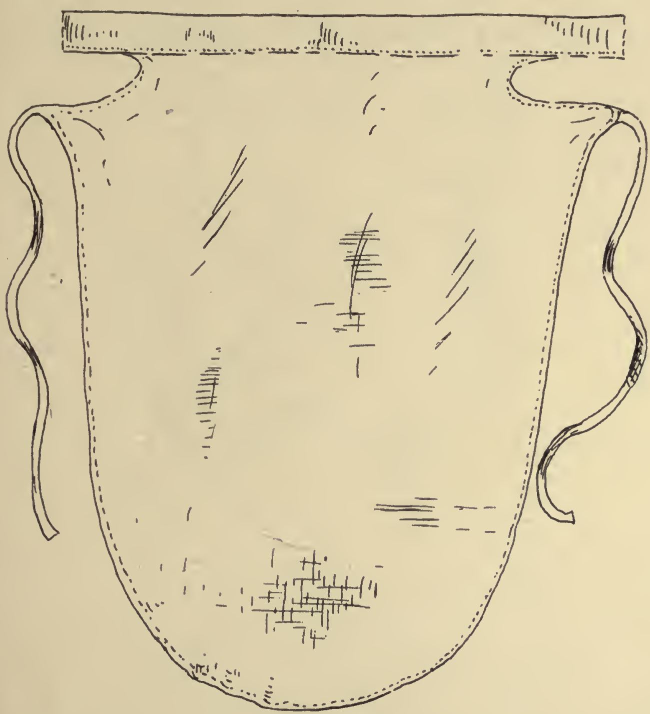

Fig. 43.
Outline Drawing of Material for Nurse's Cap.

for ties. When finished the cap will present the appearance sketched in Fig. 43. To adjust it, pin the straight, wide hem firmly around the forehead, with the material hanging over the face like a veil. Throw the latter backward over the hair; give the tapes one tie under the chin; then pass them around to the back of neck and tie, thus confining the part hanging down. The head, all except the face, is thus thoroughly enveloped, the cap having much the appearance of those worn by nuns.

In special cases when the nurse is intimately associated with the operation, she should wear mask and gloves as pictured in Fig. 45, to complete logically her costume.

THE GENERAL MANAGEMENT OF AN OPERATION.

The *arrangement of the equipment,* as well as the placing of the operator, assistants and nurses during the operation are matters influenced by many different factors; by the operator, whether he is ambidextrous or not; by the nature of the operation; by the positon of the patient, whether sitting or lying; by the kind of illumination and its source; by the sort of anesthetic to be used and by the number

Fig. 44.
Nurse's Cap Complete.

of assistants. It is, consequently, futile to lay down any but general rules. The principal consideration for each surgeon is to develop from the conditions by which he is surrounded some sort of system that will insure the least possible delay and friction in his work; and to allow time for the development of what is best for operations that are novel or likely to be fraught with special difficulties. In clinics attached to general hospitals with training schools, where nurses and assistants are frequently changing, it will amply pay the surgeon never to take anything important for granted, but rather to assure himself that everything is in readiness and within easy reach before beginning every operation.

Fig. 45.
Nurse completely dressed in Cap, Mask, Gown, and Gloves.

The *position of the patient* is a point which calls for special comment. There can be no doubt that the recumbent is the most advantageous posture for him to assume. It offers the operator the greatest freedom of movement; permits the aseptic coverings to be most easily retained in place, most efficiently helps the patient to steady himself; and is much less marked by syncopal attacks than is the erect attitude. This last feature, so fraught with distress to the one affected, and so disturbing to the routine and tranquillity of the operation is comparatively common with the sitting position and constitutes of itself a sufficient plea for the exclusive adoption of the prone position.

Visitors and Other Spectators of Eye Operations.

Operative ophthalmology must always be taught in small groups, as it is impossible for more than a very few men (from three to six depending upon the number of assistants employed and the kind of operation) to obtain a satisfactory view of what is being done. Some surgeons, even men of great experience, are made so nervous by the presence of spectators that they should never operate in their presence. Every operator must decide for himself to what extent he can do this and yet be fair to his patient. The practice of operating before large audiences at conventions, when many of the precautions necessary for the welfare of the patient are generally unobserved, is certainly open to question.

For many reasons, too obvious to mention, near relatives of the patient should not be permitted to remain in the room while the operation is in progress; and, at other times, those that are admitted to the theater should, as a matter of routine, be properly clothed in surgical attire; and they must, of course, under no circumstances speak or in any other way interfere with the operator or impede the work of the assistants. Perfect quiet should be observed by all in the operating room; the surgeon should do all the talking. Even the assistants should only on rare occasions speak to the operator.

Preparation and Sterilization of Eye Drops and Solutions Used at Operations.

The thorough sterilization of eyedrops is attended with a good deal of difficulty. It is not sufficient to place the pure products directly into disinfected receptacles containing sterile vehicles, as is often done; because the alkaloids themselves are not germ-free and are necessarily contaminated by the unclean appliances with which they come in contact while weighing them. On the other hand, the alkaloids as a class, and cocain in particular, undergo decomposition when subjected to boiling; and there is always at least a diminished efficiency as well as a doubt as to their actual strength after they have been so treated. This fact constitutes a very serious objection to all the appliances

(Stroschein[18], Mohr[19], Hummelsheim[20], and several others) that are used for sterilization in this way. With them, also, the outside of the bottle and of the pipette is to a certain extent neglected, and contamination may occur from touching its end against the neck of the flask (Mohr). Then, too, bottles of special design are relatively expensive, generally hard to replace when broken, and often difficult to clean. If one wishes to sterilize solutions by boiling, ordinary test tubes, previously sterilized and used with aseptic droppers, answer almost if not quite as well.

For the present, pasteurization seems to be the safest and most satisfactory method of treating collyria. It gives one an entirely aseptic state both within and without the flask. Following this plan, solutions of the alkaloids of the strength required are made up with sterile water or salt solution, placed in bottles previously sterilized, and subjected to a temperature of 60° to 70° C. for from thirty minutes to one hour, for three consecutive days; or, according to another plan, the solution is heated to 80° C., and kept at that temperature in a water bath for fifteen minutes. It is then allowed to cool to 38°-36° C., and the process is repeated five or six times. Any of the numerous bottles on the market can be treated in this way; but Jones' modification of Liebreich's flask (see Fig. 46) seems to meet all the requirements. While a little slow as regards the flow of drops, it is convenient for pasteurization, is supplied with a cap and is economical of material.

When once rendered sterile a small crystal of thymol added to the solution will prevent the development of bacteria for an indefinite period [Breure p.c.]. In any case care should be taken not to have the eye-dropper come in contact with the patient's face, eye lashes or any other source of infection. Moreover the collyria should be uncovered as short a time as possible.

Sidler-Huguenin[21] found in solutions of atropine, cocain, and eserine, which had been used for a whole morning after previous sterilization, in four hundred and seventy cases, streptococci four times, staphylococcus twice, streptoccus lanceolatus once, bacterium pyocyaneum four times, and a series (fourteen times) of diplococci and bacilli which could not be easily classified. Five, however, were pathogenic. Various sarcinæ and molds were also present.

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[18]Stroschein. Ueber Sterilisirung von Atropin, Eserin, und Cocain-Lösungen nebst Beschreibung eines neuen Tropfglases. *Archiv. f. Ophthalm.*, Vol. XXXVIII, part 2, p. 155.

[19]Mohr. Ueber ein verbessertes Tropfglas zur Sterilisierung von Augenflussigkeiten. *Münch. Med. Woch.*, Vol. I, part 1, 1903, p. 742.

[20]Hummelsheim. Unsere Sterilisierbaren Augentropffläschen; Ein neues Modell. *Klin. Monatsbl. f. Augenheilk.*, Vol. XLII, part 2, 1904, p. 470.

[21]Sidler-Huguenin. Ueber Einwirkung der Sterilisationsverfahren auf Cocainlösungen und über die beste Methode Cocain und Atropinlösungen steril Aufzubewahren. *Correspond. Bl. f. Schw. Aerzte*, Bd. XXX, 1900, p. 161.

Convinced of the advantages that discs of the pure alkaloids possess in the way of more accurate dosage and stability, Magnani[22] has invented an appliance for the sterilization and convenient handling of these small commodities. It consists of a small glass tube, strong and resistant to heat, which is sharply bent upon itself and provided with a tightly-fitting cap. The tube is filled with discs and then sterilized with its contents according to the fractional method of Tyndall, care being taken not to stopper too tightly, to prevent breakage. When once prepared, the lamellæ can be kept indefinitely without fear of contam-

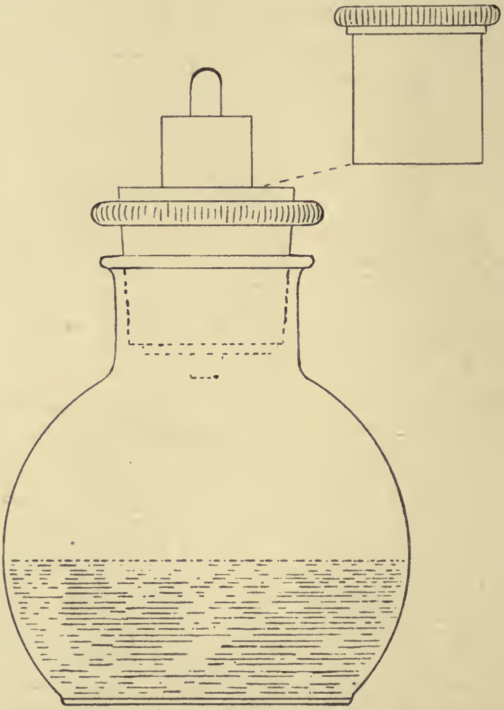

Fig. 46.
McNaughton Jones' Modification of Liebreich's Eye-Dropper.

ination, and, with a little easy manipulation, can be made to fall directly, one by one, into the eye of the patient.

The solutions used in ophthalmic operations are easily prepared. Boric acid, the one most commonly employed, is made by adding six drachms of the crystals to two pints of water. The solution is thoroughly boiled and filtered into glass flasks which are sterilized by subjecting them to steam, under pressure of ten pounds, for twenty min-

[22]Magnani. Tubi di vetro per dischi oftalmici, sterilizzabili col loro contenuto. *Giornal. della R. Acad. di Med., Torino,* 1905.

utes. The same process is used in the preparation of saline solution, which is employed in the strength of a drachm of sodium chloride to one pint of water.

Undoubtedly too little attention is sometimes paid to the renewed sterilization of these lotions; this is particularly true of solutions of boric acid, the germicidal properties of which are commonly overestimated. It has been pointed out in numerous quarters that various organisms can be grown in a saturated solution of this substance, and Klotz recently verified this in the pathological laboratory of our hospital.

Bichloride of mercury and oxycyanide of mercury are best kept in

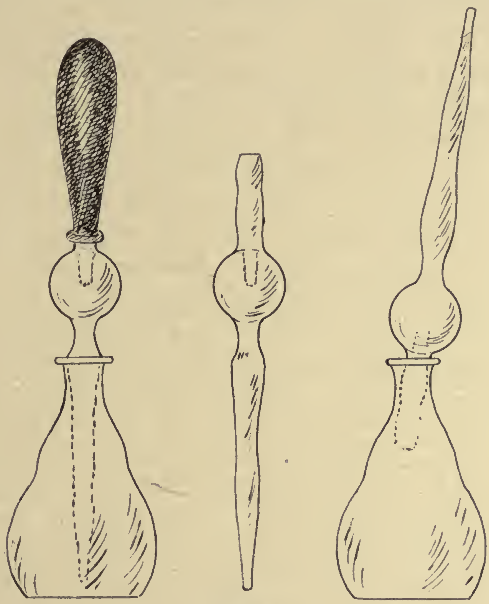

Fig. 47.
Snellen's Collyrium Bottle and Dropper.

stock solutions and diluted with sterile water to the required strengths. In using the various preparations, glass floats of different colors may be employed with advantage to prevent confusing them with one another. Their effect upon the edges of cutting instruments (a subject further discussed in this chapter) should always be borne in mind.

SPONGES, SWABS, DRESSINGS AND SUTURES.

Sponges proper are now practically never used in surgery. As substitutes one employs absorbent cotton or gauze. The former is conveniently used in the form of little balls, six of which are made up

into a small package and sterilized for one hour, on two consecutive days, under a steam pressure of twenty pounds.

Gauze *swabs* are easily prepared as follows: Take a piece of the material ten inches long by six inches wide and turn down, along one of the six-inch ends, a fold two inches wide; and then fold the stuff over twice lengthwise to a depth of two inches, making an even three-ply. By inserting the unfolded end between the turn-downed folds of the other end one forms a compact pad with no loose threads exposed.

In spite of the fact that bacteriological examinations seem to favor the open method of treatment after ophthalmic operations, most oculists prefer as a routine to close and bandage the eyes, believing that the beneficial effects of rest and support outweigh the supposed danger arising from the development of micro-organisms. The dressing commonly employed is one made up of a central pad of absorbent cotton between layers of gauze or lint. It is shaped to cover the eye properly and is generally furnished in small packages of two.

Bandages, which are now usually purchased, are still generally used; but in many clinics plaster strips to hold the dressing in place are preferred, especially in hot weather. The Liebriech or Moorfields' bandage—a band of cotton sufficiently broad and long to cover the eyes, with a notch below for the nose, and a tape at each of the four extremities to pass around the head and tie in position—is easily applied, and economical in that it can be re-employed after washing and sterilization. All these accessories, as well as towels, gowns, etc., are sterilized under steam pressure.

Silk, the suture-material most commonly used in ophthalmic surgery, is also treated in this manner. The waxed thread of Claud Worth,[23] designed particularly for advancement operations, is prepared as follows:

A reel of specially thick, black silk is wound loosely round a winder made by bending a piece of galvanized iron wire. It is boiled in water to sterilize it and to remove the superfluous coloring matter. It is then dried before a fire. The end of the silk is then threaded through a large glass bead. The bead is then dropped into a glass beaker containing a very hot mixture of white beeswax, three parts, and white vaseline five parts. The whole of the silk is drawn through the boiling mixture, and is wound on a large glass reel. It is kept in a sterilized glass jar, always ready for use without further preparation.

PREPARATION OF INSTRUMENTS USED IN OPHTHALMIC OPERATIONS.

Of all preoperative precautions none is so important as the sterilization of the instruments; and for this purpose nothing is so easy and

[23] Worth. *On Squint*, p. 204.

so perfectly certain as simple boiling in a 1 per cent. solution of soda for a period of five minutes. Equal reliance may be placed on disinfection by dry heat; but the process requires much more time (one hour at 150° C.), and it is apt to give rise to troublesome deposits on the instruments. The single objection to boiling is, that it dulls the edges of cutting instruments; and this widespread conviction has alone led to the development of other methods for treating these appliances. Walter B. Lancaster (p. c.) points out, however, that this impairment of the sharpness of cutting instruments, which undoubtedly occurs, is not attributable to the boiling itself, but to "associated causes that may be readily eliminated; and that, in view of this fact, there is no necessity of any other method to supersede boiling, so unapproachable in its certainty, speed, simplicity, and availability."

"Instruments are sometimes injured," says Lancaster, "by boiling; but I say without hesitation that this is always the result of improper methods, particularly the use of sterilizers, the metals of which are acted upon by the boiling solutions. I have seen this happen in a large hospital and be the cause of a by-law forbidding the boiling of knives. When, however, it was pointed out that the lining of the sterilizer in use was a composition of copper, tin, and lead, and that, when steel and nickel instruments were boiled in it, chemical changes were active and destructive, a new apparatus was bought and boiling of the instruments resumed without further damage. Boiling water, which contains nothing in solution but potassium hydrate or sodium hydrate, will not injure steel knives by any chemical action, even if repeated hundreds of times. If any damage is done it will be found on investigation that something else got into the water; or, more often, that the harm was done after the knives were taken out, and because they were placed in some harmful solution, such as boric acid, carbolic, normal salt, etc. It is not surprising that oculists should have fancied that boiling would injure instruments, or that the error dies hard; but general surgeons are unanimous in favor of boiling instruments in alkaline solutions, and this is very weighty testimony."

Small *portable sterilizers,* which may now be secured in several different quarters, obviate the necessity of carrying to operations instruments already prepared; but, if only one or two instruments are required, the points can be protected by wrapping in absorbent cotton and the whole safely carried in a sterilized towel or dressing. Glass tubes, of the type suggested by Grosse[24], which contain small instrument racks capable of hermetical closure by a screw-cap for sterilization, are now furnished by several dealers. Gerson[25] recommends wrapping the knives in absorbent cotton and dipping them in spirits of soap, which, when dried, forms an impermeable covering. See, also, Dr. Woodruff's Chapter on Hospital Equipment.

Of the larger sterilizers especially designed to meet the requirements of ophthalmic surgeons, mention must be made of those of

[24]Grosse. Asepsis der Instrumente, Verbandmittel und Medikamente in der Augenheilkunde. *Klin. Monatsbl. f. Augenheilk.*, Vol. XLIV, 1, 1906, p. 219.

[25]Gerson. Seifenspiritus als Desinfiziens Medizinischer Instrumente. *Deutsch. Med. Woch.*, Vol. XXVII, part 2, 1902, p. 777.

Grosse (*loco cit.*) and of Wicherkiewicz,[26] which are so arranged that everything necessary for the performance of the operation—instruments, drops, dressings, etc.—can be simultaneously prepared.

When the process of boiling is completed, care must be taken, as Lancaster indicates, not to place the instruments in any solution which will discolor them or impair their sharpness. They are best dipped in simple sterile water, which removes the soapiness of the soda without producing these effects. It is safer practice, for two reasons, always to dry the instruments before using them; first, because they are less likely to slip in the hands; and, second (and more important), because, when a solution is employed, drops of it, which invariably cling to the fingers, are very liable to run to the point of the knife, and in doing so carry infection from the hands to the wound unless the most rigid asepsis is observed.

Of all the substitutes which have been brought forward for boiling,[27] absolute alcohol is, in English-speaking circles at least, the one most commonly employed; but I wish here to point out how ill-founded is the faith in that disinfectant. At my suggestion Tytler and Wright undertook for our clinic a small series of bacteriological examinations which, while intentionally incomplete, were yet sufficient to show that no reliance could be placed on sterilization by this substance, thus corroborating the earlier conclusions of Randolph and others.

Needles inoculated with the bacillus typhosus and then wiped gave growths in broth after an immersion of as long as five minutes in absolute alcohol. The same results were noted with staphylococcus aureus, bacillus mesentericus, and bacillus coli. Cultures were not obtained with pneumococci even after one minute's exposure; but only broth was employed for the experiment. George Armstrong recommends 80 per cent. alcohol as a much more reliable germicidal fluid than either weaker or stronger solutions.

Testing the Sharpness and Competency of Instruments.

For testing the sharpness of knives, reliance is still generally placed upon the old method of passing the instruments through pieces of kid leather, practice soon enabling one to determine the condition of the edge with precision. For this purpose one employs a small ring of ivory over the end of which a bit of the material is tightly stretched and held in tension by a second ring, of slightly larger diameter, that fits tightly over the first. To make the test the drum is held between the thumb and fingers of the left hand while the knife to be tested lies

[26]Wicherkiewicz. Ein neuer sterilisierbarer Metallkasten mit Augenärztlichen Utensilen. *Klin. Monatsbl. f. Augenheilk.*, Vol. XLIII, part 1, 1905, p. 237.

[27]Special mention should be made of disinfection by formaldehyde, advocated particularly by Reik (*Phil. Med. Jour.*, Vol. III, 1899, p. 287).

crosswise in the hollow of the right. A properly sharpened knife should readily and noiselessly pass through a thin piece of the leather without any more pressure than that due to the contact of the handle with the skin of the hand.

A balance for more accurate knife testing has been described by Priestley Smith.[28] It consists of a sort of measured see-saw and is pictured in Dr. Guilford's chapter.

Scissors, punches and the like should always be tested to make sure that they will not catch at a critical juncture during the operation. Instruments of this kind act smoothly for a much longer period if, after drying in the ordinary way and before they are returned to their case, the joints are gently warmed over a spirit flame and oiled from time to time. A thinned out piece of cotton wool, used dry, or wet with some solution that will not injure the edges, makes a useful object upon which to test the sharpness of the blades.

THE PREPARATION AND DISINFECTION OF OPERATING ROOMS.

While undesirable from many points of view, it is occasionally necessary to operate in some room of a private residence. The arrangement of such a room must follow the lines already laid down for the theater of a hospital, but it is generally best to leave the carrying out of the details to a properly trained nurse, who should be allowed ample time to see that everything is in readiness. In these cases the thorough disinfection of the room to be used for the operation constitutes a very important step in the preoperative technic; and at my request T. A. Starkey, Professor of Hygiene, McGill University, has kindly described the best method of accomplishing the result.

"There is nothing apparently more simple than the disinfection of a room in an ordinary dwelling, preparatory to an operation; still there is certainly no work which the medical man may be called upon to perform wherein he may so easily 'trip up' and so render valueless a great amount of labor by the omission of some trifling detail. The success attending modern surgery, apart from the main ideas of the operation itself, depends largely upon the attention to details. Sepsis of wounds is nowadays almost unknown, and its absence is, so to speak, taken for granted, but among so many things taken for granted the condition of the operating room, or more precisely the preparation of the room by disinfection, is a matter which is not paraded as part of the operation, but, which, nevertheless, is a necessary item amongst the 'details' already referred to.

"In hospitals, etc., the preparation of the room is left to the nursing staff, and hence the medical man doesn't usually bother his head about such a matter, but in those cases where operations have to be performed in private houses the case is totally different; *there* the medical man is compelled actively to supervise all the preparatory arrangements, including the room.

"The choice of a suitable room is important. Obviously an apartment containing immovable materials, e. g., tapestry or upholstery, which it is impossible to sterilize, would be entirely unsuitable. A room well lighted and bared of everything, to admit the free application of a liquid disinfectant,

[28]Smith. A Balance for Knife Testing. *Ophthalmic Review*, Vol. XXII, 1903, p. 211.

is the kind of apartment recommended. It should, if possible, not be in direct communication with a lavatory compartment. The removal of all superfluous furniture, carpets and upholstery is an essential which nobody should neglect. Just the necessary tables, chairs, etc., required during the operation should be allowed to remain in the room.

"The process of disinfection which gives the best and surest results can be practised by any medical man wherever he may be situated, viz, the one wherein liquid antiseptics are employed. There is really very little choice amongst the liquid disinfectants because all, except one (carbolic acid), are ruled out for one reason or another. The surfaces of most household articles, e. g., tables, chairs, etc., are greasy, and therefore watery solutions of all disinfectants (except carbolic acid) will not act upon them. In popular parlance 'the solution will not bite upon a greasy surface.' Again, certain solutions, for example bichloride of mercury, potassium permanganate, iodine, etc., either stain intensely, or actually injure articles, or, lastly, are rendered inert by some chemical decomposition. Cost is another consideration, in view of the quantities required, as will be seen later. By selection, therefore, the choice is narrowed down to carbolic acid. The crude variety is the most serviceable; besides being much cheaper it is in reality a stronger antiseptic, bulk for bulk, than the pure crystal. Take a bucketful of solution of crude carbolic (1-30) and apply it by means of a mop and floor-cloth to all the floor, tables, chairs, and as much of the walls as are washable, like marble, cement plaster and woodwork. The use of the mop is advisable owing to the strong caustic action of the liquid upon the hands, the floor-cloth being reserved for those surfaces where 'swamping' with the solution is inadmissible, such as wiping ledges and walls. Too much care cannot be taken to insure the thorough and complete application of the antiseptic to all parts of the room, including nooks, crevices and ledges. Particular attention should be paid to places whereon dust can collect. These are the small details upon which so much stress was laid in the beginning. The walls and ceiling of ordinary houses are rarely washable, but, fortunately, on bare walls and ceilings dust is least liable to stick, so that if they are carefully gone over in every part with a floor-cloth wet with the disinfectant, all the dust can be effectively removed. The cloth ought to be sufficiently wet to dampen the wall covering, but not to flood it with the liquid. It must be remembered that rooms whose walls are covered with a material not having a smooth surface, which cannot be washed or wiped clean, should be rejected in the choice of an operating room.

"After allowing the disinfectant to act for three or four hours, or longer if possible, a final cleaning up can be made with clean hot water to get rid of the excess of carbolic acid. Subsequent to drying the room is ready for use.

"Gaseous disinfectants under such conditions and for such purposes are not recommended. The results obtained are too uncertain, and where surgical operations are concerned there must be no uncertainty as to the conditions under which the operation must be performed. Gaseous disinfectants, especially formalin, have their strong advocates, and under certain conditions there is no doubt as to their disinfectant properties, but experience has shown how very frequently in the average house these 'certain conditions' are absolutely unattainable. This applies to formalin disinfection more particularly. In laboratory experiments with formalin, air-tight spaces are easily requisitioned and under these circumstances sterilization can readily be obtained, but in ordinary houses it is well nigh impossible to convert a room into an air-tight space in spite of all care. Briefly, the effect of formalin disinfection depends upon the degree of leakage in the space under trial; the greater the leakage the less chance of the formaldehyde killing the bacteria.

The other gaseous disinfectants, sulphur dioxide and chlorine, have their drawbacks in addition to those just attributed to formalin; hence their use in practice is very limited."

CHAPTER III.

THE AFTER-TREATMENT OF OPHTHALMIC OPERATIONS AND OF THEIR COMPLICATIONS.

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Prevention of Hemorrhage—Hemostasis—Prevention of Hemorrhage in Hemorrhagic Diathesis—Secondary Hemorrhage—The Cleansing of Wounds—Sutures and their Removal—Price Suture-Plate—Interrupted Suture—Continuous Suture—Tension Suture—Material for Dressings, and their Retention—Gauze and Cotton—Bandages, Monocular and Binocular—Adhesive Plaster—Isinglass Plaster—Patches, Binders and Shields—Sponges, Gauze and Cotton—Applicators—Colored Glasses—The Choice of Monocular and Binocular Dressings—Frequency of Dressings—Removal of Dressings—Remedial Measures—Hot Applications—Cold Applications—Leeches—Remedial Agents—Sedatives, Laxatives—Antiseptics—Treatment of Complications of Opthalmic Operations in General—Signs of Unfavorable Progress, Subjective and Objective—Infection, Its Treatment—Vaccines and Bacterines—Post-Operative Panophthalmitis—Post-operative Iritis—Use of the Cautery—Iodoform—Injection of Antiseptics—Complications of Special Operations and their Treatment—Enucleation of the Eye—Tenotomies and Advancements—Operations Involving Corneal Incision—Iridectomy—Cataract Extraction—Excision of the Lachrymal Sac—The Surgical Toilet of Ocular Injuries—Wounds of the Lids—Wounds of the Conjunctiva and Sclera—Wounds of the Cornea—Burns—Post-Operative Dietetics.

At the request of the Editor of this System I have added to the first draft a few sections dealing especially with the *treatment of the complications of operations* in general and of the more common procedures in particular. Many of the ideas and a few illustrations are repeated in other chapters. It was considered wiser to duplicate some captions closely related to the subject of operative complications rather than refer the reader to other pages which might be found with difficulty in a large two-volume treatise. It was also thought that the duplication of certain illustrations might prove more convenient to the student of the subject in hand.

Upon the completion of any operation on the eye or its appendages, the necessary steps preceding the application of a dressing are

(1) the arrest of hemorrhage, and (2) the cleansing of the wound. The procedures differ somewhat according as the operation has to do with (a) the lids, or the lachrymal sac, as after a blepharoplasty, or (b) with the tissues of the orbit, as after a tenotomy, advancement, enucleation, exenteration of the orbital contents, etc., or (c) with the eyeball itself, as after an iridectomy or cataract extraction.

The Arrest of Hemorrhage—Hemostasis.

In general the arrest of hemorrhage during or after ophthalmic operations does not present a problem of any moment. The looseness of the tissues permits the retraction and contraction of the blood vessels, and hemorrhage usually ceases spontaneously. Proper preparation of the patient and field of operation will also contribute to lessening the tendency to bleed. The administration of a laxative sufficiently long before the operation to secure an evacuation of the bowels, contributes, among other things, to the patient's comfort, lowered blood pressure and quiet. A good night's rest, the prone position in bed, the avoidance of excitement or stimulating drinks, with the administration, if it seems advisable, of a sedative, all contribute to the composed mental and circulatory condition, which bears directly on the question of post-operative bleeding. If the operation is done in a hospital, all these things are more conveniently arranged if the patient appears at least a day before the operation.

In the presence of vascular disease or nephritis additional precautions as to rest, condition of the bowels, sedatives, and the administration of certain drugs, such as the calcium salts, will tend to lessen bleeding. In certain operations, as on the conjunctiva, muscles, and iris, bleeding can be further prevented by the local use of one of the preparations of the suprarenal gland. The instillation of this into the conjunctival sac suffices for operations on the conjunctiva, such as for pterygium, but for operation on the muscles and iris the action is much more certainly obtained, together with infinitely better anesthesia, by injecting sub-conjunctivally or along the muscles, a solution of cocain and adrenalin, as advised by Robin and Bruns[1].

It should be remembered that hemorrhage is apt to be more free from an operation performed on a woman during menstruation, or on a patient suffering from sepsis.

In *operations on the lids and lachrymal sac* bleeding can usually be controlled by pressure, best made with little pads of gauze, which may

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[1]Bruns. Ophthalmic Surgery, *New Orleans Med. & Surg. Journal*, Dec., 1909.

The solution consists of one part of 4 per cent. solution of cocain, one part of 1-1000 solution of adrenalin chloride, and two parts of normal salt solution.

be wet in a hot antiseptic solution, and pressed directly into or on the wound, and held for a minute or two. Should this fail to control the bleeding, the point whence it comes should be sought for and grasped with suitable hemostatic forceps. Since the wounds are usually small, delicate forceps are advisable, such as Halstead's mosquito forceps or *serre fines*. If after the application of such means of compression for a minute or two the bleeding continues when the forceps are removed, a ligature of silk or catgut should be applied, or a suture, employed in closing the wound, should be so passed as to include and occlude the bleeding point. In general it is not well to close a wound that is still bleeding, as the blood clot that collects between the wounded surfaces interferes with their proper approximation, and also furnishes a medium for bacterial growth which plainly increases the risks of wound infection.

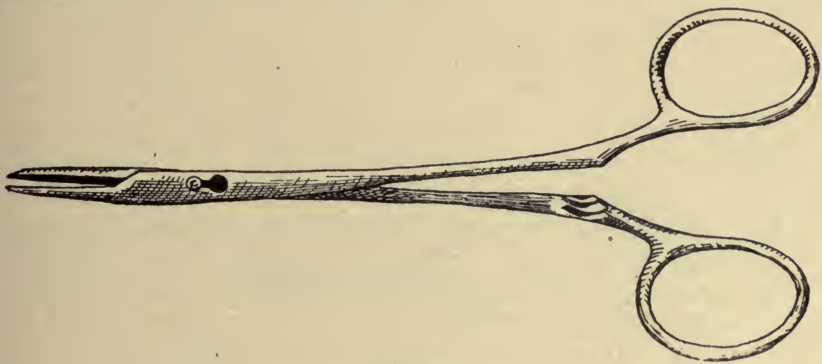

Fig. 48.
Halstead's Mosquito Forceps.

In many operations on the lids the field can be rendered bloodless, or nearly so, by the application of a lid clamp (see figure) before beginning the operation. After the completion of the operation and removal of the clamp it may be necessary to resort to some of the measures just mentioned to control the bleeding.

After *enucleation of the eye-ball or exenteration of the orbit*, the conditions are not always so simple. As a rule pressure with sponges, and the application of a firm compress and bandage will control the hemorrhage, but after these operations the bleeding may be free and prolonged. If this is apparent at the time of operation, ligatures should be applied to the bleeding vessels or the bleeding may be checked by the use of the actual cautery. If, however, the tendency is only manifested after the patient has recovered from the anesthetic, removal of the saturated dressings will reveal tissues so swollen and infiltrated with blood that the location of the bleeding point, situated deep within the orbit, is very difficult. Packing with gauze, pressure, and the in-

ternal administration of sedatives should be resorted to. These failing, the patient should again be anesthetized and the bleeding point located and tied.

In operations where excessive hemorrhage is anticipated, as in the removal of large malignant growths of the orbit, it might become necessary to expose the internal carotid artery, and pass a loop of ligature around it preparatory to tightening it if necessary to control the bleeding, or it might even be advisable to ligate it before beginning the operation.

In *operations on the eye-ball* the principal sources of bleeding are the conjunctiva and the iris. Unless the conjunctiva is much inflamed the instillation of some preparation of the suprarenal gland will prevent bleeding from that membrane. The iris, when wounded, nearly always bleeds, and sometimes bleeds very freely. This is objectionable in so far as it obscures the contents of the anterior chamber and em-

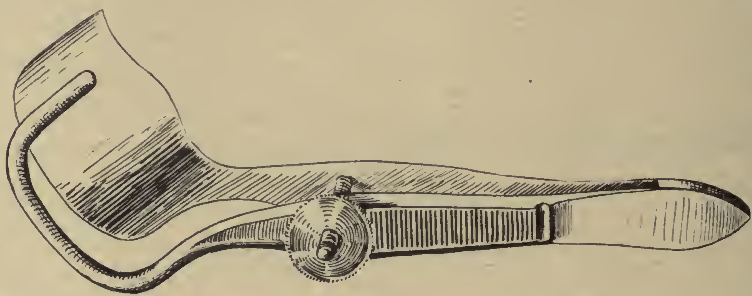

Fig. 49.
Snellen's Lid Clamp.

barrasses manipulation on the lens and other structures. The anterior chamber may fill quite full of blood, when the pressure of the blood on the cut iris will arrest the bleeding. Allowing a little time for this to occur, the blood may be expelled from the anterior chamber by the same manipulation that is employed in freeing the chamber of cortical debris after cataract extraction (q. v.). It is rarely that such measures will not insure at least a sufficiently clear anterior chamber to permit the completion of the operation, though it is conceivable that the inability to secure it might necessitate postponement of further steps. At the completion of the operation it is a mistake to submit the eye and patient to any manipulation or disturbance in an effort to free the anterior chamber of blood. In case the dressings are applied to an eye whose anterior chamber is completely filled with blood, it will usually be found in twenty-four hours to be entirely clear, so rapidly is the blood absorbed.

Before dismissing the question of hemorrhage some mention

should be made of the hemorrhagic diathesis and secondary hemorrhage.

The *hemorrhagic diathesis* (hemophilia) is fortunately seldom encountered. A patient subject to this disease may have an uncontrollable hemorrhage as an oozing from an insignificant ocular wound. Inquiry into the family history may put one on his guard, and in the presence of this diathesis nothing but a question of life or possibly that of vision, would justify a surgical operation. Pressure is perhaps the best means to combat such a hemorrhage. A detailed description of this condition may be found in most works on general medicine and surgery.

Secondary hemorrhage arises from the dislodgment of the clots by which nature has arrested the hemorrhage primarily. It is usually due to sloughing, following infection. Here too, pressure is the most efficient single means of controlling the bleeding.

The Cleansing of the Wound.

Hemorrhage having been arrested, the wound and surrounding parts should be carefully cleansed of blood. Such clots as cannot be readily removed by irrigation and gentle wiping with gauze or cotton sponges, should be picked out with fine forceps, such as iridectomy forceps. This is generally the best way to remove clots from the conjunctival sac, since it can be done with least disturbance to the patient. Sponging or wiping in this situation may excite "squeezing" on the part of the patient, with disastrous results, a circumstance which would be particularly deplorable after the completion of the operation.

Sutures and their Removal.

A word should be said here in regard to *sutures,* since their presence and their removal constitute one of the important problems in the after-treatment of ophthalmic operations.

The *material for sutures* and its preparation has been elsewhere described in this *System.* Suffice it to say that silk and cat-gut are the materials most used, and both should be black (iron-dyed) or otherwise colored to facilitate easy recognition for removal. This is assisted in the case of conjunctival sutures, by the use of the *suture plate* devised by Geo. Price, of Nashville. It consists of a small silver plate, oval in shape, and about 9 x 5 mm. in size, with two holes in it, through which the ends of the suture are passed and the knot tied on the plate, which in turn lies smoothly on the ball. In certain muscle operations, where a bunching up of the tissues included in the suture is not desirable, the suture plate serves to hold them flat.

After operations involving incision in the skin in the region of the eye, accurate apposition of the edges of the wound should be secured,

as early healing is thereby promoted and the subsequent scars are rendered much less conspicuous. In case the sutures are used to secure apposition only, and little if any tension is put on them, they should be removed in twenty-four hours, as they have by that time served their purpose and their further retention can only lead to irritation.

It should be remembered that the use of sutures is to secure apposition, while bandages give support. Sutures are foreign bodies, and should be dispensed with at the earliest possible moment. Where they

Fig. 50.
Price's Suture Plate, actual size.

are intrusted with the holding of parts in place that would otherwise tend to be displaced, as after blepharoplasty, pterygium operations and advancement of muscles, they must be left in position longer. Under these circumstances three days for the conjunctiva and six for muscle and skin will be found to be the proper time. Gifford[2] believes that if skin sutures are touched daily with a 4 per cent. solution of nitrate of silver they can be left in place longer without exciting suppuration.

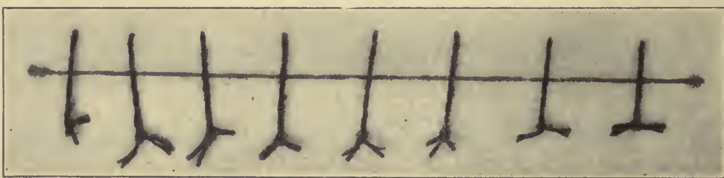

Fig. 51.
The Interrupted Suture.

Of the various kinds of sutures generally used, three common forms might be briefly mentioned here.

The *interrupted suture* is, as its name implies, composed of a series of single loops of suture material passed across the wound from side to side. The number and distance between these sutures is determined by what is found necessary to produce accurate apposition of the edges of the wound. In tying the units of this suture the ends are crossed to make a single or double knot, which is drawn down to the surface of the tissue by pulling on the two ends. Both ends are then drawn rather forcibly to one side, and the second knot tied. This

[2]Gifford. The Essentials and Non-Essentials of Ophthalmic Asepsis. *Trans. Section on Ophthalmology, A. M. A.*, 1903, p. 146.

maneuver places the knot just at the point of entrance of the suture into the skin, and not in the line of incision.

The *continuous suture,* as shown in the cut, is less often used, and consists in first passing a loop cross the line of incision. This may be tied or not. Subsequent loops are similarly passed, the suture being carried from one to the other without being cut to form single units. This suture is more difficult to remove than the interrupted suture, as

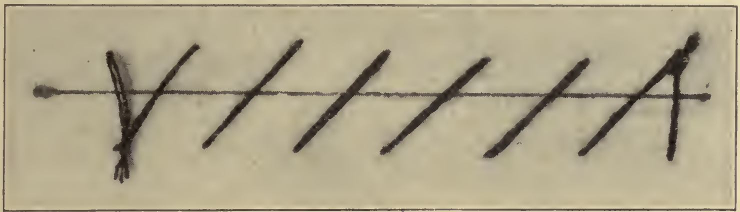

Fig. 52.
The Continuous Suture.

no part of it can be removed or loosened without interfering with the whole.

Tension sutures are used for support, as in holding flaps in place after certain plastic operations. They are generally deeply-placed sutures of heavy material, introduced well back from the wound edges, in pairs, the adjoining ends on the same side of the wound being tied over a piece of gauze or glass bead to prevent their cutting into the

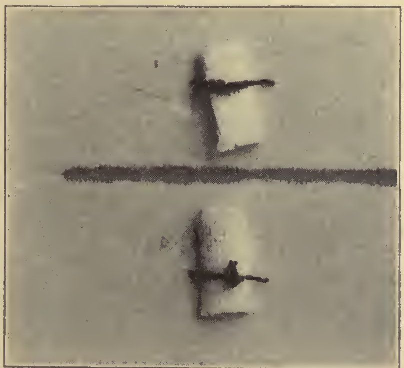

Fig. 53.
Tension Suture.

tissues. In addition to these, one of the other forms of suture is used to secure apposition of the wound.

In *removing sutures* the thread should be grasped with the points of small smooth-pointed forceps at one side of the knot and drawn out a little from its bed. It is then cut with scissors as close to the point of its emergence from the tissue as possible, and then entirely re-

moved. In this way one avoids drawing through the tissues any portion of the thread that has been exposed, and possibly contaminated, so that the risks of wound infection are materially lessened.

Material for Dressings and their Retention.

The materials used for dressing the eye after operation are principally gauze and cotton, held in place by bandages, adhesive plaster, shields, masks, patches and shades.

Surgical gauze is usually plain, not impregnated with any medicament, but sterilized by heat. A piece of suitable size and shape and two or three layers thick is applied next to the wound. If wet with a non-irritating antiseptic solution, such as boric acid, it will adapt itself more perfectly to the irregularity of the part, and thus be less apt to shift its position, though this renders it less absorbent than if applied without wetting. Some surgeons tease out absorbent cotton into a thin layer, with the fibers all running one way, and apply this, wet, next to the skin. Whether gauze or cotton be used in this way, over

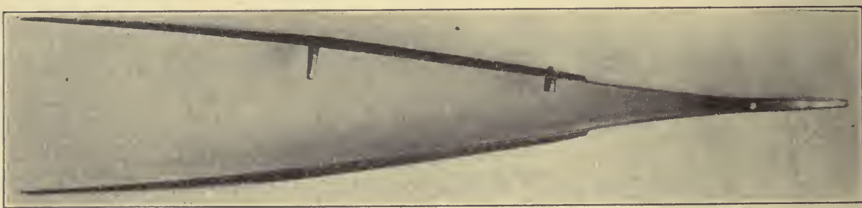

Fig. 54.
Smooth Pointed Forceps for Removing Sutures.

it is placed a pad of absorbent cotton. The size of the pad must vary with the object to be attained, varying according to whether we do or do not wish to make any pressure on the parts. In case there are cavities left in the tissues after operation, as after removal of the lachrymal sac, additional pads of gauze are so disposed as to close, by pressure, these cavities so far as possible.

It was formerly the custom with many surgeons, and is still the practice with some, to use, instead of plain gauze, that which is impregnated with some antiseptic. The ones most commonly used were the bichloride of mercury, the cyanide of mercury, carbolic acid, boric acid and iodoform. It is probably unnecessary to use any of these, in other words the dressing should be aseptic and not antiseptic, in the event of clean wounds. In the case of sloughing wounds, or surfaces, and particularly cavities, which are healing by granulation, an antiseptic gauze for dressing may have some advantages. Iodoform gauze is objectionable on account of its odor, but is thought by many to be of special value in sloughing wounds or to stimulate the granulation of bone wounds.

Cotton. The variety known as *absorbent cotton* is used exclusively for dressings, and should be tested as to its absorbability by placing a loose piece of it on the surface of the water in a glass or bowl. If properly prepared the piece will almost at once absorb water and sink; if not, it will resist the solution and float for some time on the surface. While the lack of absorbent qualities is not so important in the making of dressings, its usefulness as sponges and for the purpose of protection while irrigating is seriously interfered with if it is not properly prepared, and such a sample should be discarded.

Cotton in the packages in which it comes has been repeatedly shown not to be sterile. It can be sterilized by heat (baking) if desired, but as it is often applied outside of the gauze, it is not more necessary to have it sterile than it is to have the bandage sterile.

Bandages.

The best bandages for use in ophthalmic surgery are flannel and gauze. Flannel bandages possess a degree of elasticity which makes them very serviceable for pressure bandages, but the difference between flannel and gauze in this respect is not very great. On the whole, *gauze bandages* which can be obtained ready made in any width, are perhaps the best. Consideration of economy may prompt the use of muslin, or even calico, in hospital wards and dispensary work. Mosquito-netting of the cheapest variety and containing much starch is recommended by H. D. Bruns.[3] This is applied wet, and when dry forms a stiff but very light cast. Ocular bandages should be one-and-a-half inches wide.

An *eye bandage* is commonly applied in the form of a figure 8, and is made to cover one or both eyes according to circumstances. The *monocular bandage* is applied as follows: The end is fixed at the center of the forehead and the first turn encircles the head passing just above the eye-brows in front and just below the occipital protuberance behind. For the right eye the first turn crosses the forehead from the patient's right to left and for the left eye, from the left to right. The second turn follows the first as far as the occipital protuberance when it drops lower, passes below the ear and comes up across the pad of gauze and cotton with which the eye is covered, crosses the first turn obliquely and rests on the parietal eminence of the opposite side. Subsequent turns may be made in the same manner, and by each over-lapping its predecessor, cover the whole dressing, or turns may be made alternately around the head like the first turn, and then oblique like the second.

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[3]Bruns. Ophthalmic Surgery. *New Orleans Medical & Surgical Journal*, Dec., 1909.

A *binocular bandage* is started like a monocular. The first turn encircles the head, the second passes below the occipital protuberance and ear and up across one eye. The third turn, after passing the occipital protuberance, goes upward, crosses the parietal eminence and then comes down obliquely across the first turn, across the second eye and below the ear on the same side. Succeeding turns may be oblique,

Fig. 55.
Monocular Eye Bandage.

alternating from one eye to the other, or one may vary these with a horizontal turn.

A *single turn bandage* that is secure and quickly applied is made by taking a piece of bandage about three feet long and placing the center of it over the dressing which lies on the eye. The ends are passed around the head in opposite directions and looped around each other at the occiput, each end then going forward by the same route it followed in going backward. The two ends are then tied on the forehead.

For greater security, especially in children, the finished bandage may be covered with a single strip of adhesive plaster, half an inch wide. This is very effective in preventing slipping, a tendency which is extremely great on certain shapes of heads.

Before applying a head bandage to a woman, the hair should be plaited in one or two braids behind.

While bandages have a certain sphere of usefulness, especially

Fig. 56.
Binocular Eye Bandage.

where it is desired to make pressure, more and more is *adhesive plaster* being used instead of the roller bandage. A good quality of fresh plaster holds admirably and is much more comfortable to the patient than a bandage. Adhesive plaster, into the adhesive layer of which a certain amount of zinc oxide is incorporated, can be used with much less irritation of the skin than the plain variety, and is in other respects more satisfactory. To secure a dressing on one eye, two parallel strips may

cross the dressing obliquely, being fixed on the cheek and brow (Fig. 58), or a strip can be run along each edge of a triangular pad (Fig. 59) as advised by Casey Wood.[4] The latter is supposed to give better protection than the former, as the eye is less apt to be disturbed by the fingers of the patient and others. For applying a dressing to both eyes, a long strip is passed across both ocular regions from temple to tem-

Fig. 57.
A Simple Single Turn Bandage.

ple. Two additional shorter strips cross each dressing obliquely from cheek to brow (Fig. 60). The plaster strips should be ½ inch wide. Fixation of the dressing with adhesive plaster has the advantage, among others, over the roller bandage, of being applied and removed with much less disturbance of the patient, especially when the latter is lying in bed.

[4] Casey Wood. The after treatment of Normal Cataract Extraction. *Therapeutic Gazette*, Feb., 1896.

In place of zinc oxide plaster, *isinglass plaster* ("court plaster") is sometimes used in the same way. Some surgeons apply a strip of this directly to the lids after cataract extraction, either passing the strip across the palpebral fissure to fix both lids, or horizontally on the upper lid, to fix it, as by a splint. If one will close the lids and grasp

Fig. 58.
Monocular Dressing with Adhesive Plaster.

the eye-ball as firmly as possible with the finger tips and attempt to restrain its movements, he will be convinced of the futility of attempting to fix the eye and render it immovable by any dressing applied to the closed lids. The belief in the efficiency of a bandage, then, to fix the eye, is a fallacy, and the best we can do is to secure quiet and immobility by closing both eyes and removing the incentive to movement. This will be reverted to presently.

Besides bandages and plaster strips a variety of *patches, blinders* and *shields* are used to retain eye dressings. A very convenient one

is made of black felt, with tapes attached to each end. This is also adaptable to both eyes and answers the purpose of the old Liebreich bandage, of which it may be said to be an imitation.

A little point that should be mentioned in the application of patches, shields and masks to the eyes, especially when the patient is in bed, is to tie the ends of the tapes so that the knot will be on the side of the patient's head, and not at the back. In the latter position it is a

Fig. 59.
Monocular Dressing with Adhesive Plaster.

discomfort to the patient lying on his back, and is also inaccessible. As a hint to the nurse it might be well when first adjusting the dressing to cut one tape fairly close to the patch. The two then can be tied only at one side.

Patches of *celluloid* and *covered pasteboard* are better adapted for shading the eyes from light than for retaining a dressing.

Shields and *masks* are used for the double purpose of retaining

dressings and protecting the eye from injury, or for the latter purpose alone. They are made of pasteboard or similar material, like Ring's mask (Fig. 63), or of wire (Fig. 64), and may be used with or without any eye dressing, and cover one or both eyes. Metal plates are at times incorporated in the dressings for the same purposes (Fig. 66).

The *sponges* which are used for this and other purposes are made

Fig. 60.
Binocular Dressing with Adhesive Plaster.

by wetting a pledget of absorbent cotton, somewhat smaller than an egg, in a boric or other antiseptic solution, and rolling it betwen the palms into a little spindle with two pointed ends, and squeezing it almost dry (Fig. 67). In this form and shape it proves most useful, and when freshly made and well squeezed is sufficiently dry to be absorbent. As

Beard[5] so aptly expresses it, the tip will "drink up" secretions and excess of solution in a most satisfactory manner.

Sponges may also be made of gauze (Fig. 68), the edges being turned in so as to leave no raw edge exposed to fray out and deposit threads on the wound.

Applicators wound with cotton are used for making applications

Fig. 61.
Fixation of the Lids with a Vertical Strip of Isinglass Plaster.

to the lids and eye. For making an application to the conjunctival aspect of the lids or to other similar surface, the applicator should be wound as shown in the figure. The grasp of the tuft of cotton is made at its proximal end only, and the result is a tufted applicator, which, when wet, spreads out like a little brush. It is sometimes desired to apply a stronger solution, such as carbolic acid, tincture of iodine or other substance of this character, to a limited area of the eye or lid.

[5]Beard. *Ophthalmic Surgery*, Page 30.

For this purpose the applicator is wound in such a manner that the whole of the cotton pledget is applied tightly to the shaft of the applicator. The finger grasps the cotton for this purpose throughout the entire extent. With the applicator prepared in this manner a small quantity of a very active solution can be applied exactly where it is desired, as for instance to the surface of an infected wound.

Fig. 62.
A Patch of Black Felt for Retaining a Dressing and Protecting the Eye.

Colored Glasses.

These are used in the after-treatment of ophthalmic operations to protect the eyes from light, especially during convalescence after operation on the globe. A variety of colors is to be had, notably green, blue, amber and amethyst, but the most useful are "smoked" glasses in varying shades. If well-fitted as to pupillary distance and relation to the lashes, they offer considerable protection. The flat instead of the

coquille-shaped lens should be used, as the latter, unless carefully ground, are found to possess refractive powers equivalent to varying combinations of concave spheres and cylinders, which may be objectionable.

The Choice of Monocular or Binocular Dressing.

In considering the after-treatment of operations on the eye, the

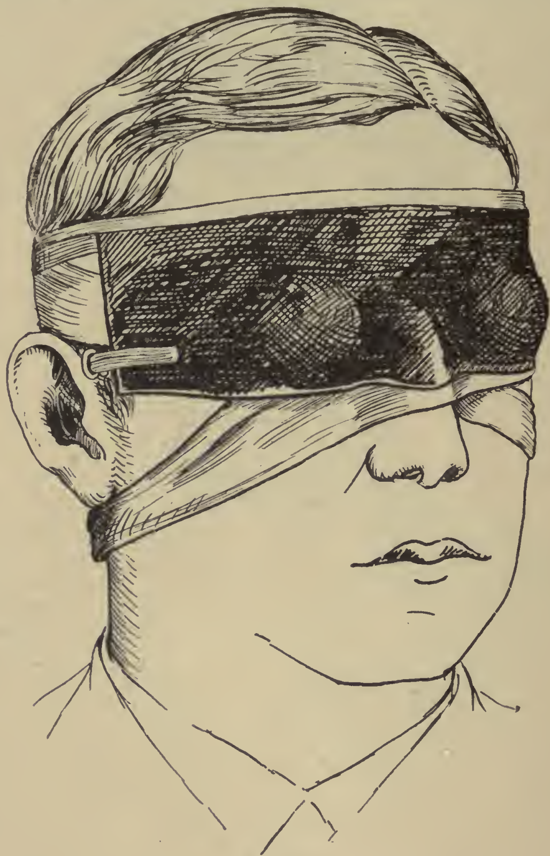

Fig. 63.
Ring's Mask.

question *whether to occlude one or both eyes* must be decided in at least two instances, namely, squint operations and cataract extraction. In all these operations the occlusion of both eyes is advocated to secure immobility and, by a period of rest, to favor the proper initiation, at least, of the healing processes. It has already been stated that no dressings applied to the closed lids can prevent movement of the ball, but there is no doubt that with the lids of both eyes closed, one will keep the eyes more quiet than with one or both eyes open. This is the argu-

ment for including both eyes in the dressing. In opposition to this practice it is argued that inflammation of the conjunctiva and secretion from that membrane are certainly increased, if not caused, by an occluding dressing, and the risks of infection of the wounds are increased. Furthermore, the covering of both eyes is said to exert at times a very disturbing effect on both the mental and physical condition of the patient, and for that reason should not be practised. In the case of an operation for squint, an additional reason for omitting all dressings is that we expect, by practice, to secure the co-operation of the two eyes in the visual act, and the sooner this is begun the better, since the union of the muscles may to some extent be induced in the manner most suitable for these conditions.

In reply to these arguments it may be said that many patients who are operated on for cataract are blind in both eyes, and whether one

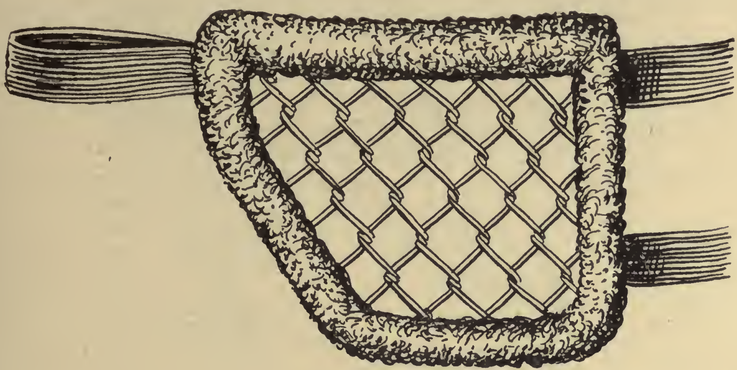

Fig. 64.
Single Wire Mask.

or both eyes are covered cannot concern them much. Even in the case of a blind eye, covering it with a dressing is apt to make it more quiet. Mental disturbance that follows this practice is not very common. Should it occur it is usually relieved by uncovering the sound eye, or both eyes, or by the use of sedatives. It can usually be prevented by not leaving the patient alone, and a bell cord or bell, placed in easy reach, so that he can summon some one at will, is often as quieting in its influence as the presence of an attendant. In squint, if a tenotomy only has been performed, it is probably never advisable that both eyes be covered, and many surgeons advise that no dressing at all be applied after this operation (Jackson[6]), but that the eyes be left open to assume the best possible position for binocular vision. If an advancement has been done the case is different. Here some writers advise

[6]Edward Jackson. *A Manual of the Diagnosis and Treatment of the Diseases of the Eye*, 1907. Second edition, p. 544.

closing both eyes for five or six days, while others, Bruns[7], for instance, advise that no dressing or bandage be applied. The practice of most surgeons lies between these two. Closing both eyes for twenty-four hours, and the one operated on for a longer time (usually till the stitches are removed, if any are to be removed) has proven a satisfactory practice, and the operative failures that have occurred could

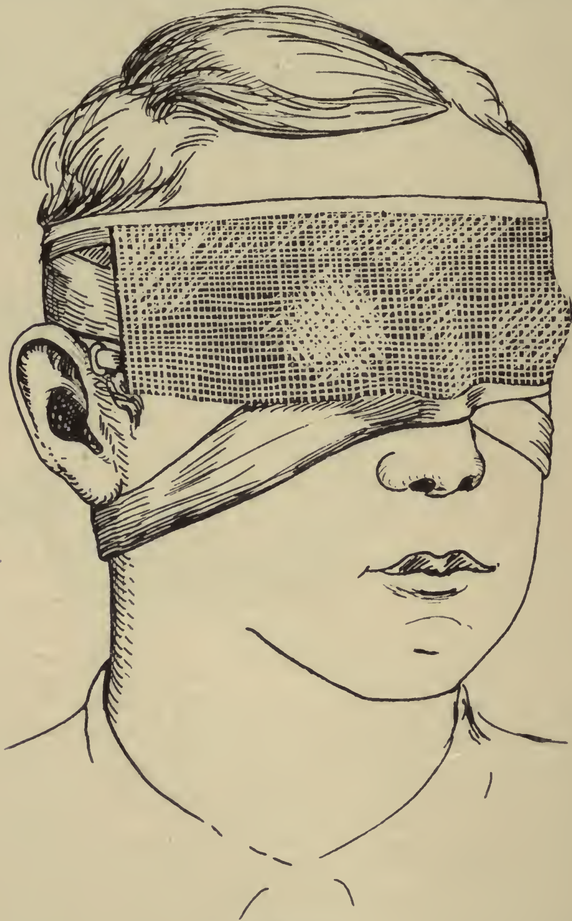

Fig. 65.
Double Wire Mask.

not fairly be attributed to the manner of dressing. In passing, it might be said that many squint operations are undertaken, and properly, for the correction of a deformity, when little in the way of improvement of visual acuity and attainment of binocular vision can be expected.

[7]Bruns. Ophthalmic Surgery. *New Orleans Med. & Surg. Journal*, Dec., 1909.

The Open Treatment After Cataract Extraction.

Something remains to be said of the practice, which has many advocates, of applying *no dressing at all after cataract extraction.* This has been advocated by a number of surgeons recently, and is the extreme position among advocates of freedom from restraint for cataract patients. It is usually advised that the eye be protected only by means of a shield or wire mask, or hollow bandage. Heinmann[8] argues that

Fig. 66.
Metal Plate Incorporated in an Eye Dressing.

this practice is less irritating to the patient, less apt to cause psychic disturbance, and that inspection of the eye is easier. The hollow bandage referred to is made of parchment paper, dipped in glycerine and molded closely to the border of the temples, forehead, nose and cheeks, glycerine jelly being used as an adhesive.[9] Glycerine jelly is composed of five parts of tragacanth, two of glycerine and 100 of water. J. W.

[8]Heimann. *Munch. Med. Wochen*, Feb., 1901.
[9]Wolffberg. Zur Technik des Holverbandes. *Woch. f. Ther. des Auges*, Feb. 8, 1900, p. 141.

Scales[10] argues against the use of the bandage; that (1) it interferes with the natural drainage of the eye and brings about a retention of secretion; (2) it interferes with uniform pressure, which the lid would exert; (3) it creates a feeling of discomfort; (4) it tends to cause entropion and (5) it causes conjunctivitis. His practice, which is adapted from Sattler, of Leipsic, is to close the eye after operation and lay on it a double layer of moist bichloride gauze. Over this a wire mask is placed. In six hours the gauze is removed and not replaced. C. Hess[11] reports "about a thousand cases treated with the open method, and the results were at least as good as, or better than, with the bandage." He has attempted to secure fixation of the eye

Fig. 67.
Cotton Spindles for Sponges, about 2" long and ½" thick.

by putting over it a capsule with an aperture in the center. The patient must look through this to see. On the whole it would seem that the following quotation from Hotz[12] pretty well expresses the views of most ophthalmic surgeons, at least in America, today on this subject.

"While we fully indorse the laudable desire to cater to the patient's comfort, we are not prepared to go in this direction as far as Hjork, of Christiania, who, in a recent issue of the *Centralblatt für Augenheilkunde*, very strongly pleads for the omission of all bandages after operations upon the

[10]Scales. Immediate After-Treatment of Patients Operated on for Cataract (without Bandage). *Trans. Sect. on Ophthal., A. M. A.*, 1907, p. 88.

[11]Hess. Discussion on Cataract. *Trans. Sect. Ophthal., A. M. A.*, 1907, p. 111.

[12]Hotz. Editorial, *Ophthalmic Record*, Vol. VI., pp. 271-273.

eye-ball. His reasons are that winking serves to cleanse the eye and carry all the micro-organisms with the tears through the normal tear passages; bandages, therefore, stopping the movements of the eye-lids, favor rather than prevent the contamination of the wound. From October, 1895, to 1896, he used a bandage, but during the first 24 hours only, and since October, 1896, he has discarded bandages altogether. During this period 112 operations by which the globe was opened were done (extractions, iridectomies, sclerotomies, needle operations), and in all cases the healing was favorable."

"We do not doubt that the puncture of a needle and the linear incisions of a keratome heal kindly under the open treatment, and even that a sclerotomy wound, unless unusually extensive, will do well without bandages,

Fig. 68.
Gauze "Bird Nest" Sponges. No Edge is Exposed. These are 1 to 1½ inches in Diameter. (Beard).

for these wounds have no disposition to gape, but close up tightly as soon as the instrument is withdrawn. But when it comes to the large curved incision of cataract extraction, we hold that kind healing requires something more than the aseptic condition of the wound; it requires in addition that the accurate apposition of the wound-edges shall be protected against disturbance by winking. The edges of these flap-wounds are easily separated by the slightest pressure of the winking lids, hence, if no bandage is used, the sealing up of the wound is retarded and the chances for prolapse are considerably increased. Hjork proves this by his own cases; for in 24 simple extractions performed during this period of the open wound treatment iris prolapse occurred four times, or in 16 per cent. of the cases. In other words,

the accident is likely to occur twice as frequently under the open wound treatment as under protective bandages. This is not a favorable showing for open wound treatment, and surely cannot induce ophthalmic surgeons to abandon protective bandages. We would advise the bandage as the safest treatment until somebody invents a cement by which a fresh wound can be firmly sealed up directly after the extraction. Then the movements of the lids could not disturb the edges of the wound, and of course, bandages could be safely omitted."

It must not be forgotten, however, that *pressure on the eye ball after corneal section should be avoided,* as it cannot produce fixation of the eye and may cause a disturbance of the lips of the corneal wound.

Fig. 69.
Method of Wrapping Cotton to Make an Applicator. (Beard).

Fixation of the eye is favored by closing the fellow eye, and guarding against startling the patient by sudden noises, etc. A dressing which closes the lids and keeps them gently closed is desirable. A bandage which maintains its position only when it exerts pressure, should be avoided.[13]

The practice in regard to the *restraints placed upon a patient after cataract extraction* has changed materially in recent years. The dele-

[13]Jackson. Effect of Pressure on the Healing of the Corneal Incision after Cataract Extraction. *Ophthalmic Review*, Nov., 1907.

terious effects, both mental and physical, of confinement on old people is well known. The most conservative methods in practice are set forth by Lawson.[14] He bandages both eyes for two or three days, the eye operated on for a week or ten days, and is careful not to let the patient walk to his bed or elsewhere after the operation. The hand on the side of the operation should be hobbled with a piece of bandage to

Fig. 70.
The Way in which the Cotton Wrapped as Shown in the Previous Figure Spreads Out to Form a Brush When Wet. (Beard).

prevent its reaching the eye, and the patient is kept in bed for a few days. The diet should be one that needs little or no chewing. At the other extreme, Lopez[15] thinks these patients need not be confined to bed at all, and that recovery is not impeded if they walk about, eat and

[14]Lawson. The After Treatment of an Uncomplicated Case of Extraction of Senile Cataract. *The Lancet*, May 29, 1909, p. 1505.
[15]Lopez. *Recueil d'Ophtal.*, Dec., 1907.

smoke in their ordinary way. Only the eye operated on is covered by the dressing. Bruns[16] bandages but one eye unless both are entirely blind, or some serious accident renders their immobilization highly desirable. He is also more and more inclined to allow patients to return to their homes after operation and report to the clinic daily, and is well satisfied with the results. The majority of American ophthalmic surgeons follow about the practice indicated by Casey Wood.[17] A light

Fig. 71.
Method of Wrapping Cotton to Make Applications of Acids and Caustic Solutions. (Beard).

dressing of gauze and cotton is applied to the eye (usually to both eyes), and held in place by a triangle of adhesive strips. The patient is transported to his bed with the least possible disturbance and effort, or if possible, he should be operated on the bed on which he is to lie. Complete rest for the next 24 hours is now in order. He should be warned

[16]Bruns. Ophthalmic Surgery. *New Orleans Medical and Surgical Journal,* Dec., 1909.
[17]Wood. *A System of Ophthalmic Therapeutics*, pp. 850, et seq.

not to talk more than is absolutely necessary, not to make any sudden movement of his body, and to refrain absolutely from blowing his nose, squeezing his eye-lids together, turning over or getting up suddenly, and above all to abstain from sneezing and coughing. If both eyes are closed it is customary to remove the dressing from the non-operated eye and to allow the patient to sit up when the lips of the corneal wound have adhered and the anterior chamber has reformed. This time can be definitely determined, while to say when the corneal wound is "healed" is not easy. In another twenty-four hours the dressings can be left off the eye operated on and dark glasses or a shade worn by day; at night a dressing with a mask or other protection is to be applied.

Frequency of Dressing.

While this will be decided in each case on its own merits, *most ophthalmic operations require daily dressing.* Since it is usual for the conjunctiva to become congested and secrete freely under an occlusive dressing, the patient's comfort, as well as the safety of the wound, is promoted by daily cleansing and airing, and this is true of all operations on the ball or adnexa when the eye is covered by the dressing. While many surgeons do not advise this plan, and allow some cases to go three or four days or a week before changing the first dressing, the more common practice is for earlier dressing, and the almost universal custom includes daily dressing after the first one is changed.

It must be remembered that we have to do with a sensitive and conspicuous field of operation, so that not only are an excess of secretion and a dry and stiff dressing sources of particular discomfort, but the head is not easily kept still and dressings about it are readily disarranged. The surgeon's aesthetic regard for the appearance of his own work prompts him to keep the dressing clean and in order—a state of affairs no less satisfactory to the patient and others concerned.

Removal of Dressings.

The hands of the surgeon should for this purpose be prepared exactly as for operation, and the patient's hair and face and the pillow be covered with sterile towels. It may not be necessary for the surgeon to put on a sterilized gown, but if he has several patients to dress, as in a hospital round, it is best to adopt this precaution.

(A very convenient tray for holding the necessary solutions and dressings at the bedside is shown in Fig. 72).

If bandages have been used they should be cut through, and *gently removed.* Let it be said, once for all, that no disturbing sight, sound, touch, application (especially of hot, cold or painful substances) or sudden movement should be permitted, lest the patient be excited to

some act, such as "squeezing," that might work to his detriment. As at the operation, *one person should do all the talking and give directions to the patient.* If adhesive plaster has been used to secure the dressing, cotton sponges (wet in alcohol for plain plaster, in ether for zinc oxide plaster) should be applied, first to wet the plaster where it adheres to the skin, and then with these same cotton sponges to wipe off the plaster, working towards the eye. The pulling off of the plaster, if done forcibly, is especially apt to excite "squeezing."

If patches or shields have been applied, the retaining cords should be untied and the patch gently removed.

The dressing itself should then be liberally wet with warm solution of boric acid, till it is thoroughly softened, and can be easily taken away in successive layers. The excess of solution which may run from the dressing should be caught in a pus basin or similar dish, or by

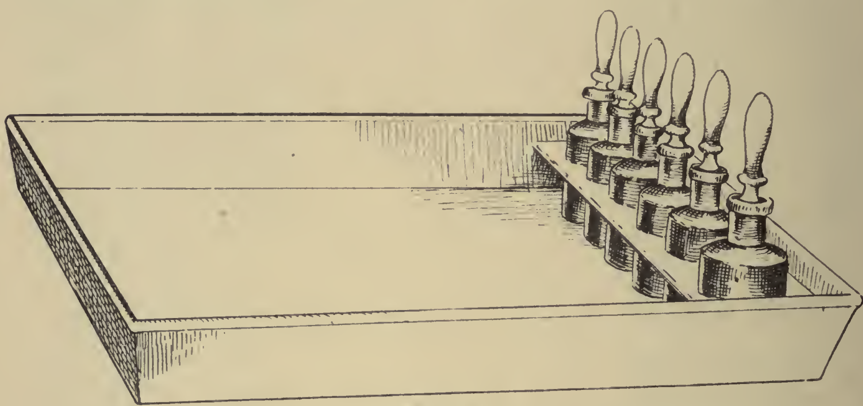

Fig. 72.
Allport's Treatment and Dressing Tray for Bedside Use.

means of a pad of dry absorbent cotton. Basins and dishes are with difficulty held so that they will thoroughly protect the patient and bedding from a wetting, and for this reason a pad of absorbent cotton seems preferable. What was said about the absorbent qualities of the cotton applies especially to that used for this purpose; unless it is of good quality water will flow over it and not be absorbed by it.

The dressings having been removed, the margins of all skin incisions should be wiped with wet cotton sponges to remove secretions or blood clots from the edges of the wound. Pledgets of gauze may be used, but the cotton sponges, just described, will be found to be more satisfactory.

Attention is next directed to the palpebral fissure, the eyes being kept closed in the meantime. A stream of warm boric solution is directed over the lids to soften any secretion that may be on them, and

the patient allowed to open the eye without assistance, if possible. Any secretion clinging to the lashes may be removed by gentle stroking with the pointed end of a cotton sponge. The patient should then be directed to look up while the surgeon draws down the lower lid and flushes the cul-de-sac with warm boric acid solution.

It is well to say here that in patients who tend to "squeeze" the eye, this tendency can be controlled by drawing down the lower lid with the thumb or finger as the first step in attempting to get the eye open, and hold it till the patient voluntarily and quietly closes the eyes. The force of the orbicularis muscle can be so broken by pulling the lower lid strongly down, that it is not likely that any harmful contraction of it could take place. As the lid is apt at this time to be moist and slippery, it may be necessary to protect the end of the finger with a layer of gauze or cotton to prevent slipping.

The solution used in this way should be warm and non-irritating

Fig. 73.
"Ear and Ulcer Syringe", Convenient for Irrigating the Eye.

to avoid shock in its application, which might otherwise cause the patient to start or "squeeze." A boric acid solution fulfills these conditions and is the one most used, although some surgeons prefer a one per cent salt solution, a half per cent sodium bicarbonate solution, etc. A convenient plan is to keep a "stock solution" in a large bottle, containing such an excess of boric acid that a layer of the undissolved acid covers the bottom of the vessel to the depth of half an inch or an inch. A sufficient quantity of this solution diluted with an equal quantity of *hot* sterile water gives a *warm* solution which answers all the requirements.

Ordinary glass finger bowls make convenient vessels for holding the solutions for dressings, being sufficiently large and easily sterilized.

The solution is applied to the eye in one of several ways. Pledgets of cotton or gauze may be thoroughly wet with it and squeezed onto the eye. This is a convenient and gentle method, though minute particles of cotton fiber may thus be forced into the eye and act as foreign bodies. A dropper of glass and rubber, a rubber syringe, undine or

other form of irrigator, may be used. A favorite method with many surgeons is to use a bottle for the solution with a large rubber dropper fitted to it as a stopper. *Whatever method is employed it is important to remember that it must be used gently.* The solution should flow on the lids or into the eye, and should not be squirted into it with any force. At the conclusion of the irrigation any excess of the solution should be taken up with a cotton sponge.

Inspection of the eye should be made, as with all other manipulations, as gently as possible. It will usually be necessary, at least at the first few dressings, to open the eye with the assistance of the fingers. *Great care must be taken not to make any pressure on the eye-ball,* and

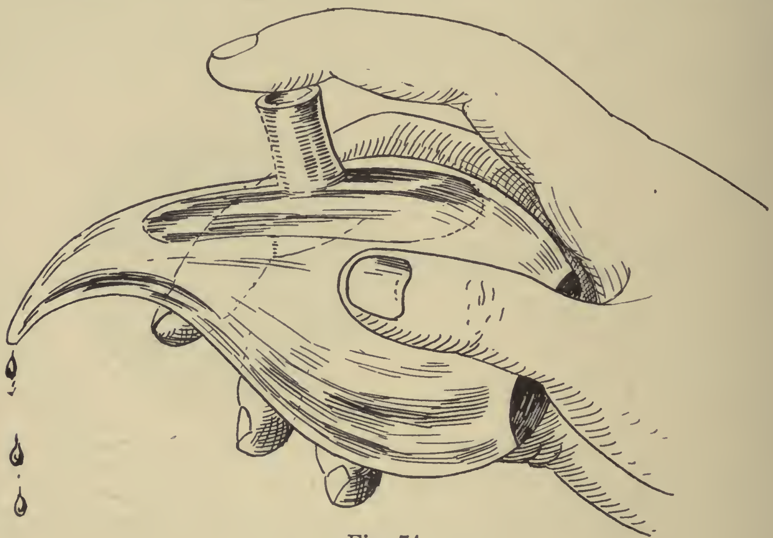

Fig. 74.
Undine, for Irrigation.

to direct the patient's actions so that he co-operates with, rather than opposes, the surgeon. *A most important matter in this connection pertains to the opposite eye.* If it is first cleansed and the patient be told to keep it open and look this way or that, the eye operated on will be found to follow the movements, and a helpful relaxation of the lids is the result. This simple means of securing the patient's co-operation is often neglected. Its value can readily be demonstrated to patients and to students by comparing the associated movements of the eyes to those of the fingers. It is very easy to extend or flex all the fingers of one hand together, but it is difficult to extend one and flex the others, or vice versa.

If an application is to be made to the eye, especially if it be painful, the patient should first be warned, lest an unexpected unpleasant

sensation make him jump or squeeze the eye, with the possibility of disastrous results. Most solutions are distinctly less irritating if applied warm, and this applies to "drops." A very good way to warm these is to first fill the dropper with *hot* water, or better with a *hot* antiseptic solution, expel this, and then draw up with the dropper the desired quantity of "drops." By this means they are sufficiently warmed and are distinctly more grateful to the patient's eye than are cool or cold solutions.

REMEDIAL MEASURES OTHER THAN DRUGS.

Hot Applications.

In the after-treatment of ophthalmic operations wet or dry forms of hot applications may be used, the former being preferable, as a greater degree of heat can truly be obtained.

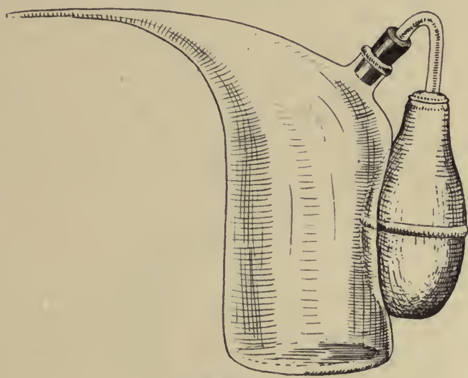

Fig. 75.
Todd's Irrigator.

Dry heat is applied with a hot water bag or bottle, Leiter's coil with a Japanese hand warmer (hot-box), with a bag of sand or salt heated in an oven, or with an electric pad or electric lamp. The latter is apt to get too hot if an ordinary 10 or 16 C. P. lamp is used, but a lamp of smaller candle power, or one with a regulating attachment, like night lamps, and "Hylo" lamps, can be so regulated as not to get too hot. In applying dry heat with a hot water bag it is well, on account of the weight, to have the patient lie with his face on the bag, rather than to lay the bag on his eye. Dry heat may be applied continuously.

Moist heat is applied by wringing a towel, pad of gauze or other cloth, out of hot water and applying it to the eye and surrounding parts. A cloth or pad only large enough to cover the eye would not be so easily handled nor retain heat so well as a larger one. In the presence of a wound an antiseptic or sterile solution should be used instead of plain water, and the whole application made with due regard to surgical

cleanliness. The pad should be renewed often enough to keep it hot, and it should be as hot as the patient can bear. Various devices have been arranged to keep the water hot at the bedside, particularly by means of a Bunsen burner or alcohol lamp and tripod, but hot water in a kettle will usually keep hot as long as needed, especially if it be placed on a fire in the room, or in a room nearby. Hot applications should be retained in place on the eye for ten to fifteen minutes at a time, or even longer if the effect is pleasant to the patient. They should be repeated every three to six hours. This all sounds somewhat empirical, but the desired effect is usually obtained when the applications are made in this manner.

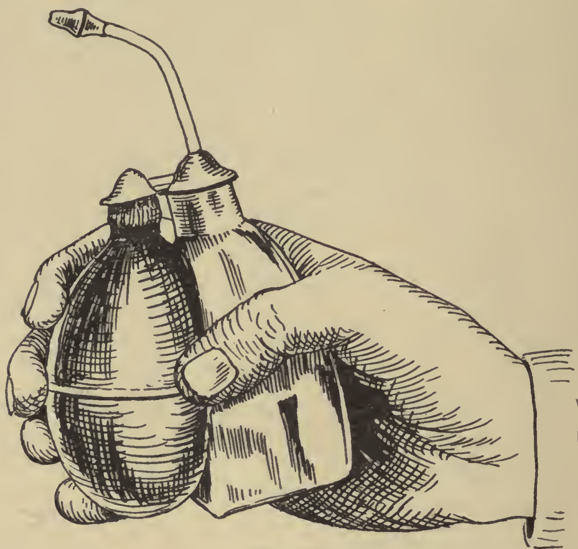

Fig. 76.
Another form of Irrigator.

Cold Applications.

Just as hot applications may be either wet or dry, so may cold.

Dry cold applications are made by means of an ice bag or Leiter's coil. The ordinary form of ice cap as used for applying cold to the head may be used, and has in its favor the fact that being of large size the ice does not melt quickly and the bag will remain cold a relatively long time. Smaller ice bags fit the ocular region more accurately, but the small amount of ice they hold quickly melts and must be frequently replenished. Dry cold is generally applied continuously.

Moist cold applications are made by preparing half a dozen pads of gauze, two inches square and six layers thick, and by placing these on a block of ice. The block of ice should rest on a towel or cloth so arranged in a basin as to keep the ice free of the water which col-

lects beneath it, and which would hasten the melting of the ice. The pad applied to the patient's eye is replaced by a fresh one as soon as it becomes the least warm. The number provided will insure a cold one being ready. These applications are usually kept up for 24 or 36 hours at a time, or longer.

Leeches.

Leeches are often used for the abstraction of blood from the temple in certain post-operative inflammatory conditions and the

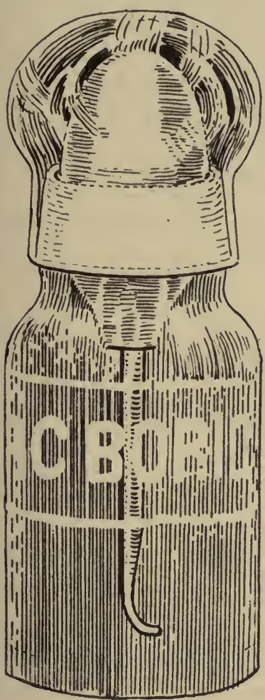

Fig. 77.
Dropper Fitting into the Mouth of the Bottle.

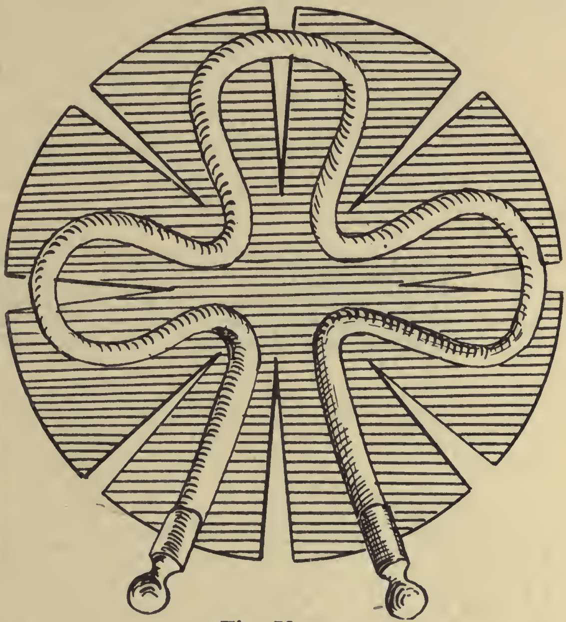

Fig. 78.
Leiter's Coil for Hot or Cold Applications.

value of the procedure is very great. Leeches are either natural or artificial.

Natural leeches, when they can be procured, are very efficient. The leech is removed from the water in which it is kept, and placed in a test tube or roll of paper, by which means the head is directed just where the surgeon wishes to apply it, the skin being previously cleansed. The application is usually made to the temple. If the leech does not readily take hold, it can be made to do so by putting a drop of milk on the skin, or by pricking the skin and drawing a drop of blood. From four to six leeches are applied and allowed to remain till

they drop off, usually in half an hour. The little wound may be permitted to bleed awhile, or the bleeding, which is sometimes quite free, can be stopped with pressure. Occasionally it is necessary to insert a suture to stop the bleeding. Leeches should not be used a second time, but fresh ones applied if the blood-letting is to be repeated.

Artificial leeches consist of two parts, a spring lancet or other device for making an incision, and a glass cylinder and screw piston for making suction. Under antiseptic precautions the skin is incised and the cylinder applied over the wound. It is often difficult to secure sufficient blood with the artificial leech, and this, together with the fact that the glass cylinders are easily broken and the plunger of the piston apt to dry up and become useless, makes the artificial leech rather a troublesome instrument.

POST-OPERATIVE REMEDIAL AGENTS (DRUGS)

In addition to the remedies already mentioned, the principal drugs used in the after-treatment of ophthalmic operations are sedatives, laxatives and antiseptics.

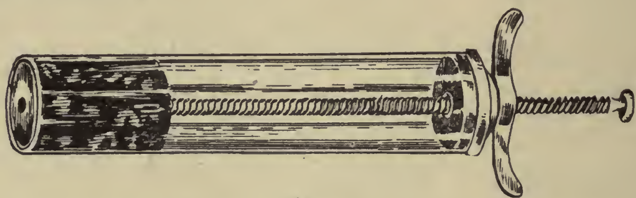

Fig. 79.
Artificial Leech.

Sedatives.

The drugs used for this purpose vary with the absence or presence of pain. In the latter case it is generally better to give at once a full dose of morphine hypodermically, or codein, or some liquid preparation of opium internally. In case of restlessness, nervousness, or sleeplessness from other causes than pain, potassium or sodium bromide in 20-grain doses, with or without chloral; or trional, or veronal, should be given. If the psychic disturbance is of an hysterical nature, valerian is a most effective remedy. The patient's idiosyncrasies should always be inquired into, and if there is some favorite remedy on which he is accustomed to rely, it had better be given unless contraindicated. The sedative value of alcohol and tobacco under some circumstances should not be lost sight of.

In the case of laxatives it is well to consult the habits of the patient, especially if he be an adult. Most people need laxatlves when confined to the house, and from the large number of salines, when it is decided to use this form of cartharsis, it is easy to select one. Epsom salts, Rochelle salts, Seidlitz powder, citrate of magnesia or any of the

various aperient mineral waters may be employed, besides castor oil, compound carthartic pills, etc. Particularly agreeable to the taste, as well as efficient in action, are compound licorice powder and citrate of magnesia. Calomel should only be given for particular reasons, not merely as a laxative.

Antiseptic and Cleansing Solutions.

Although most of these have been mentioned in the body of this chapter, it is well to furnish a more complete list. This includes:

Normal saline solution, 1 per cent.
Boric acid, 2 per cent.
Sodium biborate, 2 per cent.
Sodium bicarbonate, ½ per cent.
Bichloride of mercury, 1-1,000 to 1-10,000.
Formalin, 1-1,000 to 1-50,000.
Argyrol, 10-50 per cent.
Permanganate of potash, 3 per cent.
Carbolic acid, ½ per cent.
Thiersch's solution (salicylic acid, gr. xv,
boric acid, gr. lix to a pint).

All solutions should be made with hot sterile water, and filtered. They should be kept in closed sterile containers, preferably glass bottles or flasks.

Solutions used as drops should be dissolved in a sterile 2 per cent solution of boric acid, or, better, dissolved in the boric acid solution by boiling. This would not apply to any drug that would be injured by boiling, or to any drug not compatible with boric acid.

Powders, usually antiseptic in character, are sometimes used. Iodoform is not popular on account of its disagreeable and clinging odor, and less objectionable substances are preferable. Xeroform, aristol and acetanilid are satisfactory in their therapeutic properties and unobjectionable otherwise.

TREATMENT OF COMPLICATIONS AFTER OPHTHALMIC OPERATIONS IN GENERAL.

The signs of unfavorable progress after operations may be subjective or objective. We usually mean by "unfavorable progress in a wound," infection.

The *subjective signs* are usually the presence or absence of pain. While more or less discomfort will follow any cutting operation on the eye, it is not usual, after the operations most commonly performed, for the patient to complain, or to require any special means for the relief of pain. Patients differ very much in their ability and willingness

to stand pain, and equally as much in their conception of what constitutes pain, so that it is only exceptionally that any value can be attached to subjective signs as indicative of the unfavorable progress of a wound.

The objective signs, however, are definite and easily determined. In the *case of incision of the skin and in operations requiring skin* flaps, redness and swelling of the edges of the wound are the principal indications of unfavorable progress. It may be said here that owing to the rich blood supply of the region of the eye, wounds of the skin in its neighborhood heal quickly as a rule, and with little reaction.

The signs first seen, then, to indicate that the wound is not doing well, are *redness and swelling of the edges of the wound.* Unless checked, these processes will go on to suppuration, which more or less interferes with the objects sought by the operation. In the case of flaps and grafts, the implanted tissue may not live. This is indicated by the flap or graft assuming a dark or yellowish-gray hue, with subsequent loss of a part of it by sloughing, or by a drying or shrivelling process, usually the former. The general symptoms that accompany infection of a wound of the skin and soft parts vary very much. Usually they are moderate or absent, but if the infection is severe, or if erysipelas should develop, the general disturbance may be great. A peculiar danger that attends infected wounds of this locality is that of the infection traveling by way of the ophthalmic vein and its branches to the cavernous sinus.

The *treatment of infected post-operative wounds of the skin and soft parts* near the eye consists in the removal of sutures, the evacuation of pus and the application of a wet dressing consisting of gauze soaked in one-half of one per cent solution of carbolic acid. This should be covered with a layer of oiled silk to keep it moist, and changed daily or oftener. At each dressing pus and sloughs should be removed. When these have ceased to form, the wet dressing should be discontinued, and a dry one, composed of sterile gauze and cotton, used instead. The local treatment alone is usually all that is needed, but if there is any constitutional disturbance a calomel purge, followed by supporting treatment of tonic drugs (iron and quinine) and nourishing diet, should be carried out.

Much is promised in the treatment of local infections from the use injections of dead micro-organisms, the *vaccines* and *bacterines.* The subject is too extensive for discussion in detail here, especially as it is, at this time, scarcely beyond the experimental stage. The vaccine should be made of the same organism that is the cause of the infection, and is said to be most effective when made from cultures derived from the infected area itself. For further information on this subject the

reader is referred to the admirable articles of Jno. E. Weeks[18] and other observers.

If *infection should follow an operation on the conjunctiva or muscles* it should be treated on the same principles. After these operations, however, infection is extremely rare.

The occurrence of *infection following an operation involving the opening of the ball* is the most depressing and disastrous calamity that can befall patient or surgeon. The necessity for the early detection of this unfortunate complication, that measures to combat it may be instituted, constitutes a potent reason for early removal of the dressing and inspection of the wound after cataract extraction and other operations involving opening of the globe. The subjective symptoms are so variable as not to be reliable, and when to this is added the personal equation of the patient, who may complain bitterly of a little discomfort or not at all of a great deal, it will be seen how little we can depend on subjective symptoms to warn us of even serious trouble. This statement is to a certain extent true of the appearance of the lids; the degree of swelling in them is no positive index of trouble within the ball. The safest plan therefore is to remove the dressing and inspect the eye twenty-four hours after operation on the globe.

The lids, when exposed by removal of the dressing, will usually appear swollen and there will be some discharge from between them. It is thought that swelling of the lids near the inner canthus is particularly significant of intra-ocular infection or intense reaction, but it is seen quite often with only a moderate amount of reaction. On separating the lids a considerable quantity of thin, turbid secretion will usually escape. There is a moderate amount of conjunctival secretion as a rule, and abundant lachrymal secretion, which gives the discharge a thin consistency. The conjunctiva is found to be intensely injected and swollen. As a rule it projects around the edge of the cornea to a greater or less degree. The edges of the incision, if in the cornea, show a grayish or yellowish infiltration, the whole cornea has a cloudy look, the aqueous is turbid and the iris discolored. The infection is usually derived from the lachrymal and conjunctival secretions, or from other extraneous sources, but if from within (an infected instrument or foreign body) the signs may at first consist in a deep-seated, yellowish discoloration in the vitreous, with intense injection of the conjunctiva. Later the iris becomes discolored, the aqueous turbid, and, finally, the cornea is infiltrated. As the infective process advances the cornea becomes more and more opaque and finally melts away or separates in a more or less consistent mass, as a slough.

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[18] Weeks. The Status of Vaccine and Serum Therapy in Ophthalmology. *Trans. Sect. Ophth., A. M. A.*, 1910, p. 179.

Post-Operative Panophthalmitis. The involvement of all the tissues within the eye in a purulent inflammation is known as *panophthalmitis.* If the infection starts within the ball the cornea may resist and remain to the last, or it may become infiltrated and softened, starting from the wound and spreading across the cornea; or the infiltration may spread around the circumference rather than toward the center.

Since the treatment of such a condition is not encouraging, it might be well to dwell for a moment on the *measures used to prevent it.* First among these is careful inspection of the conjunctiva and the lachrymal apparatus, especially the latter, before undertaking any operation necessitating opening of the ball. Any disease of either should be cured if possible. If incurable lachrymal disease exists, the lachrymal sac should be removed, or the canaliculi may be tied off by passing a suture through each lid so as to include the canaliculus, as advised by Knapp, Buller[19] and Casey Wood.[20] In the presence of incurable conjunctival disease, with secretion, the conjunctiva may be incised all around the cornea, dissected loose from the ball, and after the completion of the operation proper, the cut edge can be caught up with a purse-string or other suture and brought up to cover completely the cornea.[21] In four or five days the sutures can be cut, when the conjunctiva will resume its normal position. In the meantime the corneal wound will have firmly closed.

Redness and roughness of the conjunctiva are of much less import in this connection than the presence of secretion, *whose bacterial contents should be carefully scrutinized.* Besides attention to these points, the usual antiseptic precautions as to instruments, operator and field of operation should be minutely observed.

In order to guard against infection after cataract extraction J. A. White[22] advises a careful routine, which is indorsed by others who have followed it. The most important feature of this preliminary treatment is the use of a bichloride vaseline, 1-3000[23], with which the conjunctival sac is filled for twelve hours before the operation and the eye is dressed with the same preparation each time the bandage is removed.

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[19]Buller. Temporary Ligation of the Canaliculi in Operations on the Eye. *Trans. Am. Oph. Soc.*, July, 1902, Vol. IX., Part III, p. 633.

[20]Casey Wood. Year Book of the Eye, Ear, Nose and Throat. *Practical Medicine Series*, 1903, p. 57.

[21]Ellett. A new method of preventing infection from the conjunctiva after operations involving opening the anterior chamber. *Ophthalmic Record*, Vol. 12, p. 160.

[22]White. Post-operative Infection of the Eye. *Trans. Section on Ophthalmology, A. M. A.*, 1904, p. 127.

[23]For the formula and method of preparation see the chapter on Minor Surgery.

Post-operative Iritis. Following cataract extraction, iritis is not uncommon, as evidenced by pericorneal injection or more general redness, and by adhesion of the iris to the capsular remains. To combat this form of inflammation the pupil should be dilated with atropine as soon as the anterior chamber is reformed, and the atropine continued at such intervals as may be necessary to maintain maximum dilation of the pupil. Dionin, with or without general remedies, is also of signal value. Post-operative iritis varies much in severity.

Irido-cyclitis, indicated by the severity and long duration of the inflammation, sometimes occurs, usually due to roughness in handling the eye at the time of operation. A healthy condition of the cornea and wound and the absence of pus in the anterior chamber should enable one to differentiate plastic inflammation from that due to infection, although some observers regard every post-operative uveitis as infective in character. The *treatment* is much the same as that employed for iritis, although in this connection one should bear in mind full doses of aspirin or the salicylates, given in the manner described by

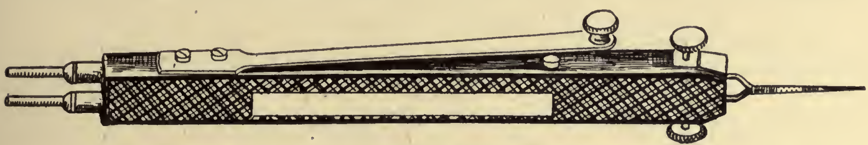

Fig. 80.
Galvano-Cautery Handle for Use in Ophthalmic Surgery.

Gifford. (See Wood's *System of Ophthalmic Threapeutics* pp. 127, 128).

Another condition that is especially apt to disconcert an inexperienced operator is what is known as *"striped" keratitis.* This is a deep-seated corneal infiltration, manifesting itself as parallel gray lines and running from the wound towards or even beyond the center of the cornea. It is caused by traumatism to the cornea, and is probably always due to the operator making too small a corneal wound, and bruising its edges in the delivery of the lens.

When *infection of the wound of operation* develops, the question of *treatment* is important and urgent. The dressings should be permanently removed from the eye. It is a well-known fact that an occlusive dressing applied to an eye will increase or cause conjunctival secretion, and this is the reason for dispensing with the dressing.

Ice compresses should be applied continuously for at least 36 hours. This will require the entire time of one person and should be carried out as already described in this chapter. If at the end of 36 hours some arrest of the infectious process seems to have occurred, the cold applications may be continued, but this is a matter for the

surgeon to decide. Cold applications are preferable to hot, in that the lowered temperature exerts an inhibiting influence on bacterial growth, though hot applications are preferred by some. The latter should be applied, as described elsewhere, for ten minutes at a time, every three hours.

The eye should be irrigated with an antiseptic solution at least every hour. Boric acid is probably the best, but bichloride and other salts of mercury, 1-5,000 to 1-10,000; premanganate of potash 1-10,000; carbolic acid ½ of 1 per cent; formalin 1-1,000; have all been recommended. The last named is apt to prove too irritating.

The wound should be cauterized throughout its entire extent. The actual cautery is best, using the galvano-cautery or a simpler device, such as the Wordsworth-Todd cautery. A strabismus hook or probe heated in the flame of an alcohol lamp can be made to answer the same purpose.

In addition to these measures some antiseptic should be frequently instilled as "drops" into the eye. Argyrol as a freshly prepared fifty

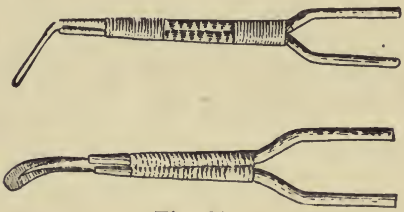

Fig. 81.
Galvano-Cautery Points for Use in Ophthalmic Surgery.

Fig. 82.
Wordsworth-Todd Cautery. The Ball is of copper and retains the heat. By means of the two projecting points the application can be accurately made.

per cent solution, is probably the best for this purpose. It is not irritating, and while laboratory tests do not give it high rank as an antiseptic, it is clinically one of the most efficient. It should be dropped into the eye after each irrigation.

The introduction of iodoform into the anterior chamber or vitreous is a measure advocated by Haab[24], Ostwalt[25] and others. Experimental study carried out by myself[26] has not been very convincing in its testimony, but it seems worthy of trial. The iodoform is incorporated with gelatin, and made into little rods to facilitate its introduction into the eye. This is accomplished by means of forceps,

[24]Haab. The Removal of Foreign Bodies from the Eye. *Trans. Section on Ophthal., A. M. A.*, 1902, p. 85.

[25]Ostwalt. Weiterer experimenteller Beitrag zur intraoculären Disinfection mittelst Jodoformstifchen. *Zeitsch. f. Augenheilk.*, VI., Sept. 1901, p. 194.

[26]Ellett. Control of Suppuration in the Anterior Segment of the Eye by the Insertion of Iodoform into the Anterior Chamber. *Trans. Section on Ophthalmology, A. M. A.*, 1903, p. 53.

either through the operative wound, or other opening, and should be repeated when the first rod is seen to be absorbed.

The injection of antiseptic solutions into the eye-ball, into the orbit, and under the conjunctiva, has also been advised. The solutions are generally of some salt of mercury, preferably the cyanide, in the proportion of 1-3,000 to 1-1,000. This procedure (q. v.) is to be recommended, since it does not interfere with other treatment and some good results have been reported from its use. Bourgeois[27] prefers the oxycyanate, 1-1,000.

It is unfortunately true that when infection involves an eye after the extraction of cataract, an iridectomy, or removal of a foreign body from the vitreous, the eye is nearly always destroyed in spite of all our efforts to prevent it. Therefore when the infective process has advanced to a point where, in the judgment of the surgeon, the destruction of the eye is certain, much time and suffering can be saved by evisceration or enucleation. It requires no small degree of moral courage to advise the enucleation of an eye on which one undertook a cataract extraction but a few days before, with every prospect of restoring the function to the eye, and possibly for this reason the operation is frequently not done under these circumstances. It is a question too, as to how much risk there is under these circumstances of enucleation being followed by meningitis from infection of the sheath of the optic nerve, but Randolph[28] has recently shown that the risk is very small.

COMPLICATIONS OF SPECIAL OPERATIONS AND THEIR TREATMENT.

The complications that may arise during or following the performance of ophthalmic operations in general (hemorrhage, infection, etc.), have been dealt with in the preceding pages. While the complications of particular operations have been treated under their appropriate headings, it has been deemed advisable, even at the risk of repeating some of the matter detailed in other chapters of this System to mention here at least some of the special accidents and complications of the more common operations, and the measures at our command to combat them.

Enucleation of the Eye.

It is usually advised to have the stump of one of the eye muscles, generally the internal rectus, left long enough to afford a grasp for

[27]Bourgeois. Treatment of Infection after Cataract Operations. *International Med. Congress*, Lucerne, 1904.

[28]Randolph. The Question of Enucleation in Purulent Panophthalmitis, with a Brief Experimental Study of the Subject. *Journal A. M. A.*, June 18, 1910, p. 2023.

the forceps, whereby the ball may be subsequently steadied. If this is not done on this muscle, some other should be so left. Should this hold not prove sufficient the ball may be grasped with the thumb and finger, or it may be dislocated forward after the muscles are all cut, allowing the lids to close behind and hold it. Or a spoon, with a fissure in the bowl, may be passed under the ball and the nerve fitted into this fissure. In the case of phthisical eyes the best fixation is secured by passing a strong suture through the ball before beginning the operation and controlling the ball by means of it.

The *eye ball may burst* in removing it, especially if its coats are ulcerated or otherwise thinned. More careful dissection is called for to insure a clean removal, and if the contents of the ball are septic, infection of the operative field is more apt to occur. Extraordinary efforts at disinfecting the wound should be used.

Especially when the ball is collapsed, but even under ordinary conditions, the *scissors may button-hole the sclera* in dividing the muscles, or in cutting the optic nerve. Except that the subsequent steps of the operation are more difficult and tedious, no special harm is apt to follow, though a bungling operation is a source of chagrin to the operator. If a piece of sclera is cut out from the posterior pole of the eye in attempting to sever the nerve, it had best be searched for and removed, together with a section of the nerve.

Tenotomy and Advancement of Muscles.

It may happen that the surgeon *fails to penetrate the capsule of Tenon* and to pass the hook beneath the tendon of the muscle, but pushes it between the conjunctiva and capsule, where it meets little or no resistance. With the bloodless field made possible by the suprarenal preparations this is not apt to happen, but it is a possibility to be borne in mind by the beginner.

The most common complications in muscle operations pertains to the *stitches cutting out* of both muscles and sclera. Many ingenious methods exist for placing sutures in the muscular tissues so they will not cut out, the best being some plan of *tying* the suture, as in the Worth operation. Scleral anchorage is more of a problem. Sutures passed deeply and at right angles to the line of traction are most secure. By bringing the muscle forward and attaching it to the scleral stump of the tendon, a secure fastening is easily obtained, and in the proper position on the ball. Many operations (e. g., Hulen's) prepare for the contingency of the suture cutting out by having additional or secondary ones placed to tie in case of need. Some such plan is very desirable until a method is devised that will prevent this complication from arising, as without it the only thing is to watch the eye slowly

return to its original faulty position to be corrected by a fresh operation.

The *tearing out or breaking of a suture* at the time of operation may be avoided by care or remedied by the introduction of fresh sutures.

It is important in these and other operations where sutures are employed that *no knot or end should touch the cornea,* as corneal ulceration may be thereby induced, with the possibility of most disastrous results.

Operations Involving Corneal Incisions.

These may be complicated by a variety of accidents.

Wrinkling of the cornea may occur in old people. When the chamber refills the cornea resumes its normal shape, and this accident need occasion no alarm.

A *bubble of air may enter the chamber.* It will disappear, or may be stroked out with a spatula just as blood and cortical matter are removed. If let alone it will be absorbed.

Prolapse of iris into the wound may occur, either with the iris simply engaged in the wound or projecting through it. If let alone this condition may result in a distorted pupil, irregular healing of the wound, iritis, infection, immediate or remote, glaucoma or sympathetic ophthalmia. An attempt therefore should be made to replace the iris by manipulation with a spatula. In this way the iris can often be replaced, and a round pupil and a free wound secured. If from the size or position of the wound, or other reason, the iris will not remain in place, but continues to prolapse, it should be grasped with forceps, drawn out a little from the wound, and then cut off. Unless it is drawn out from the chamber a little it may be found that the pillars of the coloboma (cut edges of the iris) are as unruly as the original prolapse, and cannot be replaced within the chamber.

Should this be the case, or should an excision of the iris have been the original operation, and prolapse of the cut edges appear, the edges should be repeatedly replaced by passing a spatula through the wound and onto each half of the iris in turn at as near right angles as possible with the edge of the iris wound. By moving the spatula toward the center of the pupil the iris is unfurled and spread out smoothly, and will usually remain so. Otherwise additional pieces must be removed from the pillars until they will remain in place.

If some of the iris remains in the wound, we have the condition resulting as hernia or "*healed-in-iris.*" Sometimes this causes a permanent dark spot in the line of the wound, and sometimes the scar is white throughout, as if no iris was caught in the wound. Such a

scar is firm, not unsightly, and not a cause of trouble, and can result from a very considerable prolapse. On account of the possibility of this favorable termination, a prolapse of the iris that cannot be cleanly excised satisfactorily replaced on account of adhesions that have formed between the iris and the edges of the wound through which the knuckle of iris protrudes, may be let alone. Other alternatives are incision of the prolapse with a knife, or cauterization with the actual or chemical cautery, both of which plans tend to produce a flat white scar.

There may be *delay in the closure of the wound*. This is usually due to the inclusion of a portion of iris or lens capsule or lens matter between the lips of the incision. Careful toilet of the wound should prevent this, or if it occurs some such cause should be carefully searched for with a magnifying lens and good illumination, and removed. Occasionally a corneal wound will be slow to unite without apparent cause.

The *wound, once closed, may reopen*. This may occur as the result of increased intra-ocular tension, or from pressure on the eye. The dangers of such an accident are hemorrhage, prolapse of the ocular contents and infection. Rest is the principal agent in bringing about a closure of the reopened wound.

In making a corneal incision *the knife may not penetrate the whole thickness of the cornea,* but pass between the layers, splitting the membrane. The incision must be made over.

The *incision may be made too short* for the performance of the contemplated operation. It may either be enlarged with scissors or a blunt-pointed knife, or the operation postponed.

Iridectomy.

Besides the complications enumerated as occurring with incisions of the cornea, there are a few others that pertain to an iridectomy. Hemorrhage into the anterior chamber has been mentioned.

Detachment of the iris may occur, usually as the result of some unexpected movement of the eye after the iris is grasped with the forceps. As clean an excision of the fragments as possible must be made, and especial care exercised to see that no tags remain in the corneal wound.

The *iris may be button-holed,* and the sphincter left, instead of a section of the whole width of the iris being removed. This can be avoided by grasping the iris at the pupillary margin with the iris forceps preparatory to its excision. Should the little bridge be left, it can be engaged with a blunt hook, and either broken or drawn out and cut off.

Cataract Extraction.

Premature escape of the aqueous may not interfere much with the operation, but if it occurs before the counter-puncture is made it may be necessary to postpone the operation until the anterior chamber reforms.

The *iris may be caught on the point or edge of the knife blade.* If it cannot be disengaged the incision should be completed regardless of injury to the iris, which can be subsequently trimmed up to make a neat iridectomy.

The *knife may be entered upside down.* If the blade is narrow it can be rotated to the proper position, or it can be withdrawn and the operation postponed.

Choroidal hemorrhage may occur at any time after the corneal incision. It is due to rupture of the choroidal vessels when their support is removed following the emptying of the anterior chamber. The patient experiences pain, depression, shock and sometimes vomiting. The wound gapes and vitreous and then blood flow from it. This may immediately follow the corneal incision, or may come on several hours later. Treatment is of no avail and the eye is always lost.

Prolapse of the vitreous may occur, either before or after delivery of the lens. If before the delivery of the lens, the vitreous (and iris) which have prolapsed should be excised, and the delivery of the lens effected with as little pressure on the ball as possible. It is usually best to deliver the lens under these circumstances with a wire loop or lens scoop.

If the lens has been delivered and the vitreous prolapses, the speculum or lid elevator should at once be removed, the lids closed and eye left quiet for a moment. Loss of vitreous is often due to muscular spasm, in which event the recti participate, and if all disturbing influences are removed the spasm may subside, and the prolapsed vitreous recede. Otherwise it should be excised as close to the ball as possible, and the toilet of the wound gently completed.

The *lens may be dislocated* during extraction, especially in cases of fluid vitreous. Should this occur it is usually best to wait a while, and if the lens does not reappear in the pupillary space, to close the eye and apply a dressing. It is said that the cataract will sooner or later reappear in the pupillary space, and may then be extracted.

The *lens may be expelled by the patient "squeezing"*—orbicular spasm—at any time after the corneal section. Often this is accompanied by prolapse of the vitreous.

Excision of the Lachrymal Sac.

The accidents most apt to happen in connection with this operation are *failure to locate the sac* and *rupture of the sac* during its

extraction. The first can be avoided by locating the lachrymal crest and cutting down on it. It is a sharp ridge of bone that forms the anterior boundary of the groove in which the sac rests.

Rupture or puncture of the sac during the exposure is an unpleasant accident, as the contents thereof, often purulent, may infect the wound, and the clean removal of the sac is made less easy. If any of the mucous membrane lining the sac is left behind, a new sac will form from it. It should be the surgeon's object therefore to remove the sac intact, which is accomplished by careful dissection, and with dull dissectors. Should rupture occur, thorough disinfection of the wound is necessary, and after as clean a removal of the sac as possible the whole cavity should be curetted. It will probably then be best to pack the wound with gauze and have it heal by granulation.

SURGICAL TOILET OF OCULAR INJURIES.

It may be stated here that the wounds of the eye and its appendages (operative and other) are treated on the same principles of surgery that should govern the treatment of all wounds, namely, cleanliness, restoration of parts to their normal positions and fixing them there, and the removal of hopelessly damaged parts.

The Post-Operative Conduct of the Removal of Foreign Bodies.

This is fully described in Würdemann's chapter on the Surgical Treatment of Ocular Injuries.

Wounds of the Lids.

If extensive or in children it may be best to give a general anesthetic when it is necessary to apply dressings. The parts should be thoroughly washed with soap and water, applied with gauze or cotton and not with a brush, and if greasy, as after some accidents in factories, a preliminary cleansing with sweet oil should be carried out. It has been pointed out by Crile[29] that the hands of those working in grease and oil require much effort to cleanse them, and since the grease and oil are not in themselves particularly objectionable, it is best not to try to remove them at all, as the tissues will be subjected to further bruising and the end sought will probably not be attained. This might be borne in mind when similar conditions are present about a wound of the lids.

Careful *search is to be made for foreign bodies* in the lids, especially when the nature of the injury renders the presence of one possible.

It is rarely necessary to condemn and remove any flap or tag

[29]Crile. *Surgery, Its Principles and Practices*, edited by W. W. Keen, 1906, p. 884.

of the wounded lids, but all should be carefully cleansed and replaced. The wounds should be closed with silk, using either the interrupted or the continuous stitch. The former stitch is preferable, as being more adaptable and permitting of a part of it being removed without affecting the whole line of suture. *If the wound involves the lid margin, especial care is necessary to secure accurate apposition of the wound edges.* It is better to employ a stitch which will penetrate the lid substance from its free border and lie, when tied, parallel to and just within the row of lashes, rather than to rely on stitches passed through the skin of the lid. The importance of using fine needles and suture material is appreciated by ophthalmologists, but general surgeons are prone to endanger good cosmetic results by the use of material that is too clumsy for delicate work. Stitches should be removed early, that is in 24 or 36 hours. They are foreign bodies, a source of irritation and infection, and should be dispensed with at the earliest possible moment. Their use can sometimes be dispensed with by employing, instead, narrow strips of adhesive plaster.

Wounds of the Conjunctiva and Sclera.

These wounds are treated on the same principles. It is often possible by suturing the overlying conjunctiva to avoid scleral stitches, but when necessary a fine suture, not passing entirely through the sclerotic, can be used to advantage. In general the margins of linear scleral wounds, like corneal wounds, are kept in apposition by the action of the lids, and do not need sutures. Especial care should be exercised in the case of scleral wounds to see that none of the ocular contents remain in the wound. If portions of the iris, vitreous humor or ciliary body should be so engaged, they ought to be replaced with a spatula, or if this is not possible, the prolapsed part should be excised. If the wound of the sclera tend to gape and expel the vitreous, or if the vitreous has prolapsed or presents in the wound, the scleral wound should under such circumstances be closed with a stitch or a conjunctival flap. This is important on account of the great danger of infection of the vitreous occurring when it is exposed.

Wounds of the Cornea.

These are treated on the same principles (just indicated) as wounds of the sclera. Corneal wounds are apt to be accompanied by prolapse of the iris. This hernia should be carefully replaced with a spatula. By manipulation with the same instrument the edges of the wound should be brought into the best possible apposition. If a prolapsed iris is torn, or will not remain in position when replaced, it should be drawn out a little from the wound and cut off. The iridic stump is then replaced.

Ordinarily one must rely on the lids to keep, by their pressure, the edges of a corneal wound in position, as it is seldom wise to suture a corneal wound. Corneal stitches should be made with a fine suture and a round needle, but if the corneal wound is very extensive and tends to gape, it is best to free the conjunctiva over a sufficiently large area and make a flap, which can be drawn over the cornea. By freeing the conjunctiva all around the edge of the cornea, it can be raised and brought together so as to completely cover the cornea and without undue tension. When the stitches are removed the conjunctiva will resume its normal position, there being little tendency for it to adhere to the corneal wound.

In wounds affecting the eye-ball cleanliness should be secured on the lines laid down elsewhere in this *System*.

Injuries of the Eye by Burns and Caustics.

The eye is often injured by burns of hot metal, powder, etc., and by caustics (chemical burns), such as lime (mortar) and acids. These injuries are always the cause of anxiety, since vision may be impaired from the resulting scar if the cornea is burnt, while scarcely less unfortunate are the results produced by cicatricial contraction after burns of the conjunctiva and lids.

The treatment consists in the removal of the offending substance, and its neutralization in the case of caustics. If a caustic alkali is the cause, the eye should be washed with milk. If lime, the eye should be flooded with oil, and then a solution of cane-sugar dropped into it. Acids should be neutralized with alkalies. When this is thoroughly done and all foreign substances removed, the treatment is along the usual antiphlogistic lines. If the cornea is deeply burned an opacity will result, and if the conjunctiva is burned, an adhesion of the lid to the ball (symblepharon) is to be feared. If the fornix conjunctivæ is involved in the burn, a symblepharon is almost sure to follow. It can be subsequently remedied by operation.

POST-OPERATIVE DIETETICS.

We are not confronted with such problems in the post-operative feeding of ophthalmic patients as are met with in abdominal operations, for instance, and the question is, on the whole, simple. If the patient has taken a general anesthetic, no food or drink should be given until the stomach is quiet and the nausea and vomiting have ceased. The stomach can then be tested with a teaspoonful of ice water, and if this is retained, water may be more freely given, as well as milk, broths, etc. Solid and semi-solid food should be withheld for 24 hours. After that time, or from the completion of the operation if

a general anesthetic has not been required, the patient should be put on a light diet, such as milk, cereals, eggs, soup, etc., with a few vegetables, and little or no meat, until he resumes his usual activity. In case the operation has involved the interior of the eye-ball, food that requires much chewing is usually to be avoided until the wound in the ball has closed, since the motion of chewing may disturb the eye and lids a little. Except for such precautions as are usually taken in the way of avoiding articles known or apt to cause gastro-intestinal derangement, and in the temperate employment of all kinds of food, the question of a post-operative dietary calls for no special consideration.

A question one is often called on to consider is that of the use of tobacco and alcohol after operations on persons addicted to their use. This decision should largely rest upon the amount of disturbance their withdrawal is likely to produce. If the craving is great, it is better to allow the stimulant and let it be used openly, safely and moderately, than, as may be the case, secretly, immoderately and in a clumsy or otherwise unsafe manner. The same may be said of the use of narcotic drugs by patients who are habituated to them.

CHAPTER IV.

ELECTRIC APPLIANCES AND THEIR USE IN OPHTHALMIC SURGERY.

By EDGAR S. THOMSON, M. D., New York.

The Electro-Cautery—Historical Review—Method of Use—Indications—The Operation for Keratoconus—Electrolysis—Method for Removal of Hair Follicies, Xanthelasma, Lachrymal Stricture, etc.—Transillumination—Historical Review—Method—The "Tumor Reaction"—The "Shadow" Method—Details Shown—The Electric Ophthalmoscope—Advantages—The Electric Retinoscope—Electric Head Mirrors—The Ophthalmo-Diaphanoscope—The Electric Spud and Knife Needle—The Sideroscope—Instruments of Asmus, Gĕrard and Hirschberg—Siderophone of Janssen—Value and Limitations of These Instruments—X-Ray Apparatus—Use in Treatment of Various Diseases—In Diagnosis of Tumors or Sinus Disease—In the Localization of Foreign Bodies—Value and Applicability—Historical Review—Principles of the Various Methods, "Geometric," "Anatomic," and "Stereoscopic"—Methods of Sweet, Mackenzie-Davidson, Hulen, and Dixon—Advantages of Dixon's Method—Ramsay's Modification of Mackenzie-Davidson's Method—Method of Guilloz—Magnets—Historical Review—Magnets of Hirschberg, Sulzer, Snell, Gruening, Bradford, Hubbell, Haab, Schlosser, Johnson, Lippin cott, Mayweg, Sweet, Volkmann, and Mellinger—Comparison of strength of Large and Small Magnets—Foreign Body Injuries—Size of Particle—Situation—Character of the Injury—Diagnosis—Selection of the Magnet—The Operation—The Anterior Chamber Route—Modifications of the Method—Difficulties—The Scleral Route—Comparison of Methods—Results of Magnet Operations.

THE ELECTRO-CAUTERY.

The electro-cautery, as made at the present time, consists of an iron-clad motor generator, as shown in Fig. 83, and a transformer for converting the direct into the alternating current. The transformer, which is fully protected, is contained in the base of the outfit on which the motor is mounted. The current is controlled by a wheel which regulates the strength and indicates the amount on a graduated scale. The current is received from the street, or lighting, current, where possible, although a small storage battery or else a permanent battery and rheostat may be used. Two insulated wires are attached to screws in

the cautery and run to the handle, which contains a button for making and breaking the current, and into which the point is inserted.

In using the cautery, the point selected is inserted into the handle, the wires are attached to the motor, the button is pressed down, completing the circuit, and the indicator on the motor is pushed forward on the scale until the requisite amount of heat is secured. The button is then released and the cautery is ready for use.

Various points are shown in Fig. 84. They are made of copper wire with a loop of platinum at the tip, which becomes white-hot as the

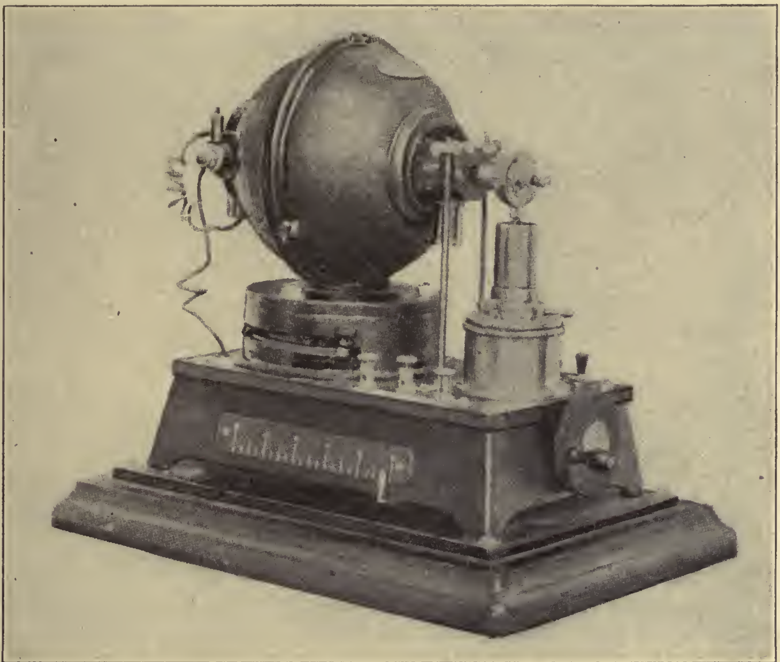

Fig. 83.
Electro-Cautery.

current passes through it. The handle and wires should be light and easily manipulated, and it is especially important that the button for making the current should work easily so as to require the least possible effort, leaving the operator's hands free to exercise the greatest possible delicacy of touch. The shape of the point is largely a matter of individual preference. Where small surfaces of the cornea are to be touched, the fine, small tip is best; in fact, it is always better to work with a small point and have the applications accurate than to use a large point, which is less easily controlled. For large surfaces, as the base of a corneal papilloma or the margins of a malignant ulcer, etc.,

a larger point than those in the cut may be used, but is not by any means essential. A special form of point, with a circular end, has been devised by Knapp[1] for use in perforating the cornea in keratoconus (see figure). This form is almost essential for this procedure.

Historical Review.

The actual cautery was known to the ancients and was used in a variety of conditions. In modern times, the first use of the cautery in corneal ulcers has generally been credited to Martinache[2], who claimed to have originated the procedure, although the editors remark: "The old surgeons made such free use of the actual cautery that it would be strange if they never resorted to it for this purpose." Martinache employed an iron probe heated to a white-heat, and reported good results from its use. Samelsohn[3] advocated the use of the cautery in certain conjunctival affections. Gayet[4] advocated strongly the actual cautery as opposed to chemical cauterants, especially in abscess of the

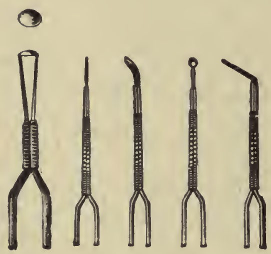

Fig. 84.
Cautery Points.

cornea. Legroux[5], chief of clinic of Gillet de Grandmont, first introduced the electro-cautery, which has largely taken the place of other methods of cauterization on account of its greater convenience and efficiency. He used a fine platinum thread energized by a "pile secondaire de Planté," and mentions in particular its use in phlyctenules of the conjunctiva and cornea. After this there were numerous papers on the subject, and good results reported. Neiden[6] reported a series of

[1]Knapp. *System of Diseases of the Eye.* Norris and Oliver. Vol. 3, p. 825. 1889.

[2]Martinache. The Actual Cautery in Ulceration of the Cornea. *Pacific Med. and Surg. Jour.*, Nov., 1873, p. 290.

[3]Samelsohn. The Galvano-Cautery in Ophthalmic Surgery. *Archives of Ophthalmology*, Vol. 3, No. II, p. 124, 1874.

[4]Gayet. De l'emploi du cautère actuel dans le traitement des maladies de la cornée. *Gazette des Hôpitaux*, 1877, No. XI, p. 86; also Cautérisation ignée de la cornée. *Soc. de Chirur. de Paris*, Jan., 1877. Vol. 3, p. 79.

[5]Legroux. Du traitement de la phlyctène conjunctivale et kératique par le cautérisation galvanique. *Ann. d'Oculistique*, Vol. 81, 1879, p. 181.

[6]Neiden. Modification des Sattler'schen Schlüssels. *Bereicht ü d.* 16 *Vers. d. Ophth. Gessells.* Heidelberg, 1884, p. 125; also, Ueber die Anwendung

well observed cases with excellent results. At the present time, the use of the cautery, and particularly the electro-cautery, has become so well established that it is a well recognized form of treatment in many ocular conditions, and has a wide share of usefulness.

Method of Using the Electro-Cautery.

In using the cautery the eye should be well anesthetized and held in the proper position, if the cornea is the seat of disease, by speculum and fixation forceps. Some surgeons prefer to lay the tip on cold and

Fig. 85.
Method of using the Electro-Cautery.

then, after bringing the tip to a dull red heat, quickly remove it. This plan is advocated by Knapp.[7] The present writer, however, agrees with

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der Galvanocaustik in der Ophthalmotherapie spec. der destruc. Hornhaut-process *Archiv f. Augenhlk.*, 1885, Vol. 14, p. 336; also, Die zweite Hundert reihe galvanocaustisch behandelter Augenaffectionen. *Archiv f. Augenhlk.*, 1885, Vol. 15, p. 405; also, On the use of the Galvano-Cautery in Eye Diseases, Especially in Destructive Processes of the Cornea. *Archives of Ophthalmology*, 1885, Vol. 14, p. 31; also, The Second Series of One Hundred Cases of Eye Disease Treated with the Galvano-Cautery. *Archives of Ophthalmology*, 1885, Vol. 14, p. 455.

[7]Knapp. *System of Diseases of the Eye.* Norris and Oliver, Vol. 3, p. 823, 1898.

Beard[8], who says: "Seeing that the performance be a mere touch, it would seem that greater precision can be attained by holding the wire close to the place to be burned, heating it to the right color, then deftly making the contact." The tip should never be allowed to become white-hot, for the heat is then too great and the action of the cautery can be less easily regulated. Too great an amount of tissue may be destroyed, the light is very startling to the patient, and there is some danger of over-heating the aqueous. The point should be heated to a dull red heat, a single spot touched quickly and the point removed, and the proceeding repeated until the entire surface to be cauterized has been gone over. (See figure).

Indications for Use.

The cautery is always used to destroy tissue, whether exuberant, infected, misplaced or malignant. The electro-cautery does everything that the actual or chemical cautery does, and does it better. It is only necessary to properly regulate its effect. Its most frequent use is for *infected ulcers,* all forms of intractable superficial ulceration, and the deeper circumscribed purulent processes, whether hypopyon be present or not. The indication par excellence is the yellowish coloration of the ulcer, which indicates a more active purulent process, although the cautery may be used with advantage in cases of ordinary "grayish" ulcer in which other forms of treatment have failed to arrest the process. In the milder forms of ulcer it is sometimes well to begin with acid cauterants, of which the most useful, in the writer's experience, is pure carbolic acid. Should other measures fail, the electro-cautery is always to be thought of in any form of corneal ulceration. In certain of the more severe deep purulent processes, considerable judgment is to be used in the amount of burning to be done. It is a general rule, in cauterizing, to destroy all infected tissue, but in the deep infiltrations of certain infected injuries, especially in those of advanced age and of the alcoholic habit, a too free use of the cautery is apt to be followed by local reaction and a further extension of the corneal necrosis, and so a word of caution is necessary. The most satisfactory results are to be expected when the infected tissue can be completely destroyed with but little destruction of the sound tissue surrounding, and without too great a lowering of the local resistance. The ulcer should always be well cleansed before cautery is applied, and in certain cases it is highly serviceable to stain the ulcer with a two per cent solution of fluorescin which stains all the denuded surface a brilliant green and renders the field of operation clearly visible.

The cautery is very serviceable in destroying the infiltration at the tip of a vascular leash, in fascicular keratitis, and also in destroying the

[8]Beard. *Ophthalmic Surgery*, 1910, p. 379.

vessels themselves. It must first be determined that the process is an exuberant and not a conservative one, before destroying the vessels—which is to be decided by the clinical course of the case, and the constitutional tendencies of the patient, as well as the local appearances—and then the cautery is applied at the limbus so as to cut through the entire thickness of the leash. There is, as a rule, very little reaction, and the results are good. Indeed, it is surprising how little reaction follows the use of the cautery in the cornea, provided that it is used with the proper caution.

The cautery is almost essential in destroying the base of certain corneal growths after their removal. This is especially the case in corneal papilloma, as has been noted by numerous writers on the subject It may also be used after removal of dermoids, pterygia, etc., or in any case in which the activity of the process leads one to expect a recurrence. The flat point is more useful for this purpose. After the growth has been removed as thoroughly as may be, the whole surface is lightly seared over. Knapp[9] states that he has cauterized in this way "fully half the surface of the cornea; the recovery was by repair of almost perfectly transparent tissue, without any irritation, and there has been no relapse."

The cautery has been used in *infected wounds, especially after cataract extraction.* In the past this has been a recognized mode of treatment, much more so than at present when infection after cataract is, or should be, rare. The writer has used this method, but has grave doubts of its efficacy. In fact, the reaction is apt to be severe, and the infectious process is apt to continue in spite of the cauterization. Too often, as is pointed out by Knapp[10], the infection depends upon a conjunctival or lachrymal condition which is continuous in its effects, and the treatment of the source of the infection is of the greater importance. Besides, the local effect of the cautery seems to be to reduce the tissue resistance and at times to hasten its destruction.

The cautery has been used in certain conjunctival conditions, notably *trachoma,* but is rather a tedious method of treatment and is accompanied by a considerable amount of destruction and subsequent cicatrization. In *exuberant granulations* of the conjunctiva, low grade epitheliomas of the conjunctiva or lids, the cautery, while inferior to other forms of treatment, has nevertheless a certain value. It has also been used to obliterate the tear sac, but is a much inferior method to extirpation. Galvano-puncture is a very safe and efficient means of treatment in certain cases of angioma of the lid.

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[9]Knapp. *System of Diseases of the Eye.* Norris and Oliver, Vol. 3, p. 824, 1898.

[10]Knapp. Ibid, p. 825.

Small staphylomas of the cornea, small prolapses of the iris, fistulæ of the cornea, angular incarcerations and cystoid scars, have all been treated with the cautery, and at times good results have been obtained. The iris must be approached with caution, however, on account of its vascularity and irritability. A beginning suppurative tendency is an especial indication for the cautery. (See paper by Harold Gifford, The Danger of Sympathetic Ophthalmia from the Use of the Cautery in treating Iris-Prolapse. *Jour. Am. Med. Ass'n.*, July 30, 1910, p. 386.)

In small circumscribed nodules in episcleritis, the cautery has been used by Webster for the past twenty years. A single light touch upon the summit of the nodule markedly hastens the recovery of the case and is, in the author's opinion, a valuable mode of treatment.

Galvano-Cautery in Keratoconus.

Keratoconus has been treated by cauterization of the summit of the cone by a number of ophthalmologists, the first of whom was A. von Graefe.[11] His plan was to cut off a thin layer of the point of the cone and then cauterize the surface with a stick of nitrate of silver. The results were very uncertain.

Gayet[12] advised cauterization of the cone with the electro-cautery, with perforation of the entire thickness of the cornea. Andrew[13] advised puncture of the cone with the fine needle of a cautery. He reported a case in which the vision was improved from "fingers, with the greatest difficulty" to 20/200.

Abadie[14] advocated cauterizing a little to one side of the center of the cone, so as to avoid giving a central opacity. Knapp[15] reported five cases treated with the galvano-cautery, with good results. He had constructed the round point previously mentioned, and which is shown in the accompanying figure. The wires of the point led up a disc-shaped end, which was really a section of a surface of a sphere. This was applied vertically to the summit of the cone, which is almost always below the corneal center. The current was then turned on and the point made a red-hot, so as to rapidly perforate the cornea. Knapp found that without the perforation the cornea did not flatten well and it was necessary to repeat the cauterization once or twice. In one case in which a sharp

[11] A. von Graefe. Zur Heilung des Keratoconus. *Archiv f. Ophthalmologie*, Vol. 12, Part 2, p. 215, 1866.

[12] Gayet. Abscès superficial de la cornée; importance des caractères fournis par l'hypopion au point de vue de pronostic. *Lyon Médicale*, 1879, Vol. 30, p. 491.

[13] Andrew. On the Use of the Cautery in Eye Practice. *Br. Med. Jour.*, Nov. 8, 1884, Vol. 2, p. 903.

[14] Abadie. Thèse de Guiot, 1887.

[15] Knapp. Five Cases of Keratoconus Treated with Galvano-Cautery. *Archives of Ophthalmology*, 1892, Vol. 21, p. 540.

point was used, perforation was accomplished very slowly, so that the aqueous "did not jet but oozed out." This case developed a very peculiar looking yellowish cataract, which Knapp believed came from over-heating of the aqueous. He says: "I had never seen such a peculiar looking cataract, apart from its developing in a young and healthy eye." Consequently, he believes that the cauterization should be done quickly, without giving time for the aqueous to heat. Critchett and Tweedy[16] also commend the method, as does Panas.[17] Critchett, in the report mentioned, performed the operation without perforation, while Tweedy considered perforation essential to success. Elschnig[18] is an enthusiastic advocate of the method. The writer, in a somewhat limited experience with this operation, is prepared to agree as to its value in cases which have gone so far as to have such distortion of the visual image that they cannot use the eye. But the after condition, with a large corneal opacity—although below the center, and possibly an inclusion, or at least an adhesion, of the iris—is not sufficiently gratifying to tempt one to perform the operation unless all other means of treatment have failed and the cone has progressed ad maximum. The vision, however, is usually much improved by the operation. With the cone fully developed, a reduction to 5/200 or 6/200 is not uncommon, while the final result after cauterization is sometimes as high as 20/50 or even 20/40. The cone flattens out well, but there is at times some diffusion of light from the opacity, and it may be necessary to perform a tattooage, or even an iridectomy.

ELECTROLYSIS.

Electrolysis, or the electric decomposition of the tissue fluids, has occupied a singular position in ophthalmic surgery. It has its earnest advocates, who report excellent results from time to time, but the great majority of practitioners, from whatever cause, use it but little. And yet the apparatus is relatively simple. A continuous current 2 to 10 milliamperes is necessary, with a positive electrode fitted with a sponge, while the negative carries the needle, or whatever form of instrument may be required.

As early as 1873, electrolysis was used in general surgery[19], and various conditions of the eye have been treated by its means since that

[16]Critchett and Tweedy. A Case of Conical Cornea Treated with the Galvano-cautery. *Trans. Ophthal Soc. of the United Kingdom*, Vol. 12, 1892, p. 72.

[17]Panas. *Traité des maladies des yeux*, Vol. 1, p. 293, 1894.

[18]Elschnig. Zur Therapie des Keratoconus. *Wiener klin. Rund.*, 1904, Vol. 18, p. 357.

[19]See v. Bruns. *Handbuch der chirurgischen Praxis*. Tübingen, 1873, Vol. 1, p. 687; also J. Althaus. A Treatise on Medical Electricity. London, 1873, p. 361.

date. Probably the first, and certainly one of the most important, uses is the method for *removal of the hair follicles.* This procedure is adapted chiefly to the cases where only a few hairs are to be dealt with, as in cases of distichiasis, where the lashes grow inward toward the cornea in small groups or singly, and where the greater number of the hairs are unchanged. Such conditions are found principally in local disease of the lids which, occurring near the hair follicles, diverts them from their proper course, as in the milder forms of trachoma, certain forms of chalazia, etc. At times no cause can be assigned for the eccentric growth. Epilation is most commonly practised, but is rather productive of ultimate difficulties than otherwise, as the hairs grow constantly and are apt to become smaller and more difficult to remove in the course of time, though little less irritating to the cornea. Electrolysis offers us the only sure means of destroying the hairs without excessive scarring. Michel[20], in 1875, described several methods for this purpose, the final one of which is practically the method of today. In 1869 he devised a cautery which consisted of a platinum point ⅜ of an inch in length and of the thickness of a No. 8 sewing needle. This was made white-hot by the passage of an electric current and then plunged into the hair root. Considerable reaction followed, although the method was successful. His next plan was to cauterize with silver. In a small platinum cup, or silver spoon, a piece of nitrate of silver was fused and the end of a sewing needle was warmed and dipped into the silver so as to coat the needle for about ¼ of an inch. The hair follicle was then split to its base with a broad pointed knife needle, and after the bleeding had been stopped the needle bearing the silver was inserted into the root of the follicle and twirled around so as to thoroughly destroy the hair root. This method also was frequently followed by reaction and scarring. His final method, as described and adapted by Beard,[21] is shown in Fig. 86. An electric outfit capable of furnishing a current of 5 milliamperes is required. The negative electrode is furnished with a fine sharp needle of gold or platinum; the positive, with a sponge which is kept wet with salt solution. The best means of determining whether or not the current is ready for use is to immerse the two poles in a bowl of water and gradually turn on the current until the needle throws off a stream of tiny bubbles, indicating the decomposition of the water. The apparatus is then ready for use. Beard advises that the operator wear strong convex lenses or the binocular stereoscopic loupe in order to bring the hair orifice plainly into view. The patient is placed upon the operating table and the lid is held by some suitable forceps (in the cut, the Beard

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[20]Michel. Trichiasis and Distichiasis: with an Improved Method for Their Radical Treatment. *St. Louis Clinical Record*, Oct., 1875, p. 145.

[21]Beard. *Ophthalmic Surgery*, p. 212, 1910.

forceps). The needle is then pushed down alongside of the hair until the point is well within the follicle (three to four milimetres), and the sponge electrode, wet with salt solution, is applied to the adjacent temple or to the opposite cheek. As soon as the boiling up of gas around the needle occurs, the sponge is lifted, the needle is withdrawn, and the hair is lifted out. The hair should come out easily and without any traction; if such occurs, it is a sign that the destruction of the root has been incomplete. Jourdan of Frankfort am Main, suggests that the needle be dipped into shellac and then a small portion of the end un-

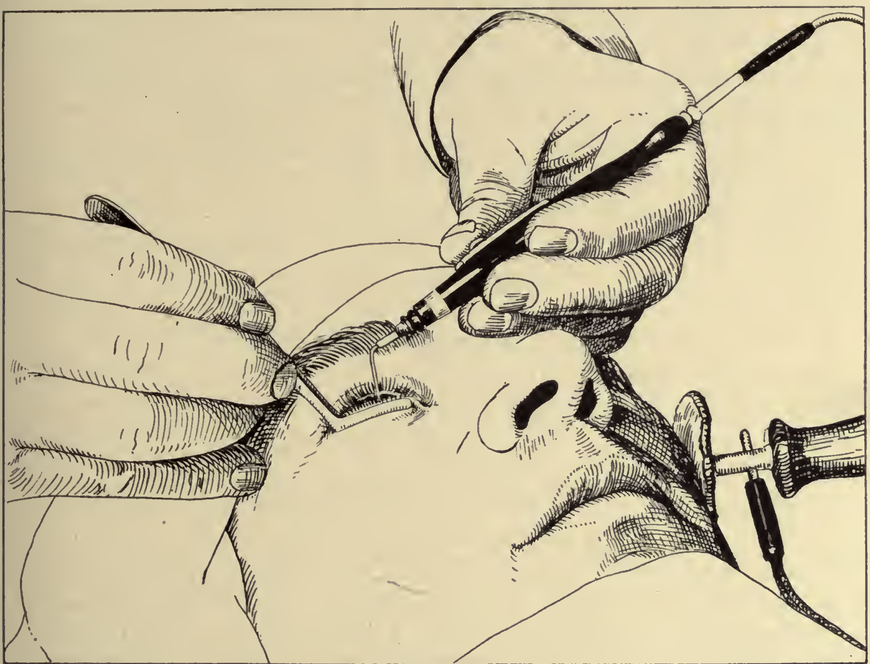

Fig. 86.
Electrolysis of the Cilia (Beard).

covered by scraping. This protects the sensitive skin, lessens the pain, and renders less likely the formation of punctiform scars.

Xanthelasma was first treated by electrolysis by Wende[22] and later by Kellogg[23] and by Leplat[24] of Liège, all of whom reported good results. Pansier[25] of Avignon reports satisfactory results after five years'

[22]Wende. Treatment of two Cases of Xanthelasma by Electrolysis. *Medical Press of Western New York*, Sept., 1888.

[23]Kellogg. Electrolysis for Xanthelasma. *Annals of Ophthalmology*, April, 1897, p. 334.

[24]Leplat. Traitement du Xanthome par l'électrolyse. *La Clinique Ophtalmologique*, Jan. 25, 1902.

[25]Pansier. Traitement électrolytique du Xanthélasma. *Archiv d'Electricité Medicale*. July, 1902, p. 385.

use of the method. He punctures the xanthelasma with the negative needle and passes a current of 6 to 10 millamperes through it for 2 to 3 minutes. The number of treatments usually varies with the case. Generally in four or five days there are only a few small nodules left. Pansier believes it is better to wait 12 to 15 days between treatments. To diminish the pain, which, however, is not very great, he advises rubbing on, a few minutes before the treatment, an ointment of

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Menthol.		
Chloral hydrate	āā	3.00.
Lanolin		6.00.

Neiden[26] reports good results from electrolysis in a case of angioma of the lid. Fuchs[27] also indorses this method of treatment.

Electrolysis has also been used for the *destruction of trachoma follicles* and other conjunctival conditions, but has not found many advocates. Starkey[28] recommends it for the treatment of pterygium.

Of real importance is the *treatment of lachrymal stricture.* Lagrange[29] advocated the method and described it in detail. A specially shaped stylet is attached to the negative wire, while to the positive is attached a sponge or mass of cotton soaked in salt solution. The "positive" sponge is placed in the nostril of the same side, so that during the treatment the two poles are only about 2 cm. distant from each other. The upper part of the stylet is covered with a non-conducting material, while the lower part is bare so as to be in direct contact with the mucous membrane of the nasal duct. The intensity of the current is gradually increased up to 5 milliamperes, remains there for a few minutes, and is gradually diminished. The entire time of the passage of the current should not exceed five minutes. The proceeding is not particularly painful, and is repeated two or three times, as may be necessary. The lachrymal nasal duct is washed out with an antiseptic solution every two days following, and "not rarely" the cure is obtained from one treatment. The action of the electric sound has the advantage of being germicidal, which makes the proceeding so much the safer.[30] Beard[31]

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[26]Neiden. Ueber die Anwendung der Electrolyse in der augenärztlichen Therapie. *Archiv. f. Augenhlk.*, 1880, Vol. 9, p. 339.

[27]Fuchs. *Diseases of the Eye.* Am. Edition, p. 593, 1908.

[28]Starkey. *Jour. Am. Med. Ass'n.* Sept. 11, 1898.

[29]Lagrange. Électrolyse dans le traitement das affections des voies lacrymales. *Atti. Dell, XI. Congresso Medico Internazionale.* Rome, 1894, Vol. 6, p. 44; also, De l'électrolyse dans le traitement des rétrécissements des voies lacrymales. *Archives Cliniques de Bordeaux*, 1895, p. 399; also Technique de l'électrolyse des voies lacrymales. *Annales d'Oculistique*, Dec., 1900.

[30]Lagrange et Mazet. De l'action de l'électrolyse .sur les cultures de staphylocoques. *Recueil d'Ophtalmologie*, Oct., 1893, p. 606. See also De Renzi et Panas. Action microbicide de l'électricité. *Intern. Klin. Rundschau.* 1893.

[31]Beard. *Ophthalmic Surgery.* p. 140, 1910.

commends the method and says that "the toughest strictures seem to melt like wax before the electrically charged sound." Schoeler and Albrand[32] have investigated the effects of electrolysis upon the eyes of rabbits.

TRANSILLUMINATION.

Transillumination of the eye has been practised for some years past and has been the subject of some twenty-five or more monographs, and yet, singularly enough, the appreciation of its value as a means of diagnosis has been but slowly gaining ground.

Historical Review.

In 1884, O. Lange[33] suggested the method in connection with intraocular sarcomata. He allowed the light from a gas flame, focused by means of a convex lens to fall upon the sclera in a case in which the pupil was widely dilated by atropine. He noted that when the beam fell upon the area over the supposed growth the illumination in the pupil was much fainter than when it fell upon other parts of the sclera. A

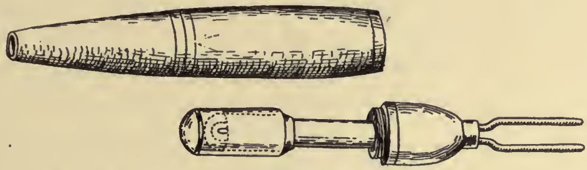

Fig. 87.
Rochon-Duvigneaud's Transilluminator.

few years later, Mules[34], in an article on tumors of the ciliary body, pointed out that a ciliary ectasis produced by a neoplasm might be differentiated from an ordinary one by allowing a beam of light to fall on the sclera and observing the amount of light in the pupil. He considered that the method could be practised only when the tissues were considerably thinned. Shortly after this von Reuss[35] presented a lamp which consisted of a small electric light, run by a small battery, enclosed in a metal case and provided with a water jacket to prevent overheating. Leiter[36] modified von Reuss' lamp by doing away with the

[32]Schoeler and Albrand. Experimentelle Studie über galvanolystische-cataphorische Einwirkungen auf das Auge. Berlin. Reference in *Centralbl. f. Augenhlk.*, 1894, Vol. 18, p. 45.

[33]O. Lange. Zur diagnose des intraoculären Sarkoms. *Klin. Monatsbl. f. Augenhlk.*, 1884, Vol. 22, p. 410.

[34]Mules. Intraocular Tumours; Tumours of the Ciliary Body. *Trans. Ophth. Soc. of the United Kingdom*, 1888, Vol. 8, p. 66.

[35]von Reuss. Vorlaüfige Mittheilung über Durchleuchtung der Augenwandungen. *Wiener. Klin. Wochen.*, 1888, Vol. 1, p. 756; also abstract in *Centralb. f. Prakt. Augenheilk*, 1889, Vol. 13, p. 90.

[36]Leiter. *Centralb. f. Prakt. Augenk.*, 1889, Vol. 13, p. 90; also *Wiener Klin. Wochenschr*, 1888, No. 37.

water jacket and employing a glass rod to conduct the rays of light. Rochon-Duvigneaud[37], in 1884, devised a lamp which consisted of a small electric light, run by a current of 10 to 20 volts, enclosed in a horn case, and provided with a glass cone 5 to 6 cm. in length. (Fig. 87). The light could be transmitted through the sclera by direct application of the glass cone, which did not get hot as in von Reuss' instrument. In 1902, Leber[38] presented his lamp, which is shown in Fig. 88. It consists of a small electric light enclosed in a metallic case. A short rod of glass encased in rubber is in contact with the light and a large amount of the light is conducted along the rod to its end which,

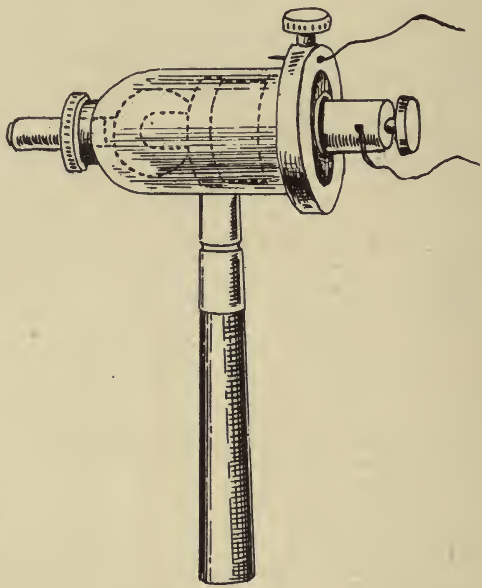

Fig. 88.
Leber's Transilluminator.

when placed upon the sclera, is capable of illuminating strongly the interior of the globe. This instrument has found considerable favor, but is somewhat clumsy to use on account of its short blunt shape and, further, gets hot after a few minutes' use. It heats rather slowly, however, and not nearly so rapidly as its detractors would have us believe. In the following year Sachs[39] presented his lamp, which was a great addition to our equipment. It consists of a twenty-five candle power

[37]Rochon-Duvigneaud. Examen. par transparence du segment antérieur de l'oeil. *Bull. et Mem. de la Soc. Francaise d'Oph.*, 1894, Vol. 12, p. 293.

[38]Leber. Demonstration eines einfachen Durchleuchtungsapparates des Auges. *Bericht ü. d. 30 vers. d. Opth. Ges.*, 1902, p. 319.

[39]Sachs. Ueber eine neue Durchleuchtungslampe und ihre Verwendung in der Augenheilkunde. *Münch. Med. Woch.*, 1903, Vol. 50, p. 741.

electric light which is covered by a metallic spherical case of about 3 inches in diameter. It bears a cone-shaped projector of glass which extends from the side of the bulb, at right angles to the handle, as shown in Fig. 89. The glass projector is silvered around its circumference so as to secure as great a conservation of the light as possible, and is covered by a casing of hard rubber. This instrument gives fine results, but is somewhat heavy and cumbersome to handle in the delicate manipulations that are necessary. The bulb gets very hot after a few minutes' use, but the rubber cone, which is applied to the eye, does not. There has been much error upon this point, several writers speaking of the Sachs lamp as if it were impossible to use it for more than a few min-

Fig. 89.
Sachs' Transilluminator.

utes on account of the heat. While it is very inconvenient to have the bulb so hot, necessitating great care to avoid burning the patient's cheek or brow, the projector does not get appreciably warm after fifteen or twenty minutes' use, and the lamp can be used for a sufficient time to study each case, as the writer has demonstrated repeatedly. The unwieldiness of the lamp is a much more serious and just criticism, and it is difficult to manage it properly in exploring as far back as the equator. In 1906, Lange[40] presented a new model which is designed

[40] Lange. Zur Diaphanoscopie des Auges. *Klin. Monatsbl. f. Augenheilk,* 1906, N. S., Vol. 1, p. 362.

to meet one serious limitation in the usefulness of other lamps. It consists of the usual outer case, of hard rubber in this instance, containing a small electric light requiring 10 volts. The end of the case is capped by a nickel clasp which holds a glass rod 5 cm. in length, Fig. 90. The end of the rod is slightly curved and ends in a blunt point which permits one to apply it farther back over the equator. It is favorably mentioned by Stephenson[41], who considers it a "most efficient appliance." At the meeting of the American Medical Association in 1906, Würdemann[42] presented his lamp, which is certainly one of the best. It consists of a tube, about the size of an ordinary fountain pen (Fig. 91), containing a small electric light, in the end of which is a covered glass rod, 2.5 cm. by 5.5 mm. The light has an additional thickness of glass on the end, which acts as a small lens and which is in direct contact with the end of the rod, thus conserving nearly all the light. The rod projects a fraction of a millimeter beyond the hard rubber cone, in which

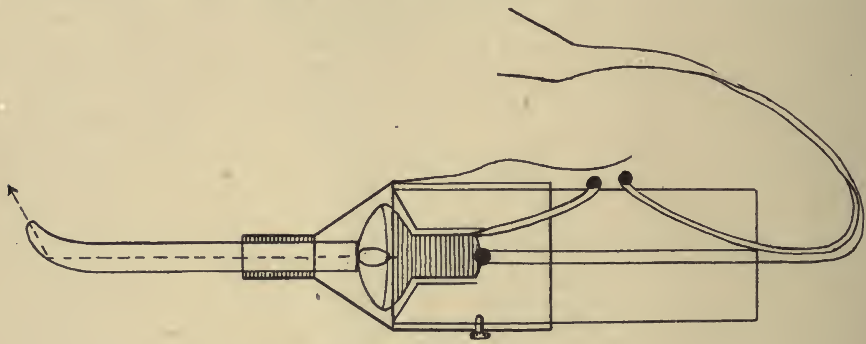

Fig. 90.
Lange's Transilluminator.

the instrument ends, and can be placed directly on the bulbar conjunctiva, even without cocainization. The light is of 5 candle power, requiring less than 1 volt of current. This lamp does not heat as much as many of the others. Fridenberg[43] has recently modified Würdemann's lamp by constructing the glass rod in the shape of a hook. The curve begins as soon as the rod emerges from the case and is very abrupt. The end of the rod is flat and tipped back so that when the transilluminator is held in the direction of the visual axis the end of the rod

[41]Stephenson. Transillumination of the Eye. *The Ophthalmoscope*, 1908, Vol. 6, p. 961.

[42]Würdemann. Diaphanoscopy of the Eye. *Ophth. Record*, 1906, Vol. 15, p. 513; also Additional Observations on the use of the Ocular Transilluminator (The Würdemann lamp). *Ophth. Record*, 1908, Vol. 17, p. 163; also Diaphanoscopy of the Eye. *Ophthalmology*. 1908. Vol. 4, p. 645.

[43]Fridenberg. *Special Presentation at Section on Ophthalmology, Am. Med. Ass'n*, 1910.

can be applied to the sclera as far back as the conjunctival cul-de-sac will allow, thus extending the field of usefulness back into the posterior segment of the globe. This is the object of Lange's construction, but his rod is long and has a blunt end. Fridenberg's is very short—in fact only a few millimeters—has a high curve and flat end, and the light is undoubtedly better conserved.

It may be said that transillumination has now become well known and is widely used. The writer reported the results of his experience with the procedure to the American Ophthalmological Society in 1905,[44] and sees no reason to feel less enthusiastic now. Papers have been written by Würdemann in 1906 and 1908, as above mentioned, by Marple[45] in 1906; by Fridenberg[46], in 1908, and by several writers in England and on the continent. One of the best recent articles is by Stephenson[47], who gives a bibliography of twenty-two articles.

Method of Transillumination in Detail.

Absolute darkness is necessary, if the best results are to be obtained. The lids are held back and the point of the glass rod is placed on the skin of the upper or lower lid, or at the external canthus, or else-

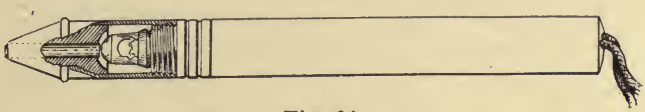

Fig. 91.
Würdemann's Transilluminator.

where, depending on the angle required. If a very strong light is required the rod may be placed on the sclera, previously cocainized, but this does not give as much better an effect as might be expected, as the tissues of the lid are easily penetrated. In the use of the Würdemann lamp it is possible in many cases to apply the end of the rod to the sclera without the use of cocaine. The observer stands directly in front of the patient, and by varying the angle of the light rays and by causing the patient to look this way and that, can study all the tissues in the anterior part of the globe.

There are two ways of using the method, which should be definitely specified on account of the lack of attention which the more important one has received.

[44]Thomson. The Sachs Lamp for Transillumination of the Eye. *Trans. Am. Ophth. Soc.*, 1905, Vol. 10, p. 457.

[45]Marple. A Case of Sarcoma of the Choroid, Presenting Some Difficulties of Diagnosis, together with an interesting Observation upon the Use of the Transilluminator. *Trans. Am. Ophth. Soc.* 1906, Vol. 11, p. 193.

[46]Fridenberg. Notes on Transillumination of the Eye. *Arch. of Ophth.*, 1908, Vol. 37, p. 302.

[47]Stephenson. Transillumination of the Eye. *The Ophthalmoscope*, 1908, Vol. 6, p. 959.

1. By observing the variation in the intensity of the light in the pupil when different parts of the sclera are illuminated (the so-called "tumor reaction.")

2. By observing the *shadows* cast on the sclera by normal or abnormal structures within the globe.

The "tumor reaction" was the origin of the method, and has been dwelt on by the earlier writers, most of whom do not mention the "shadow" method at all. The shadow method, which is certainly the more important and widely useful, has been advocated chiefly by the American writers and the later foreign writers. The "tumor reaction" is best observed with the pupil dilated. The lamp is placed over the sclera at the point at which a retinal detachment or other suspicious appearance leads one to suspect a growth, and the intensity of the illumination in the pupil is noted. The lamp is then shifted about at various points and it is noted whether the illumination is brighter outside of the suspicious area. At times when the light is on the edge of a growth a part of the pupil will remain bright while the rest will be decidedly darker. This is a very striking appearance and gives an indication which can mean but one thing. On the other hand, it is obvious that to judge of the presence of a solid growth by mere difference in the intensity of the light is a method that must be used with great care, and at best is liable to lead to certain errors.

The "shadow" method is applicable to a great variety of conditions other than intra-ocular growths, and besides, is more reliable in the diagnosis of tumors of the anterior part of the globe. It is practised by placing the rod of the lamp on one side of the globe and observing the shadow cast by the tissues on the opposite side. (Plate I.) It is obvious that the majority of cases that will show tumor reaction will also show a shadow of the growth, if it is not too far back, and will show the growth much more definitely and in a way which it is impossible to misunderstand. (Plate I.) It must be admitted, however, that if the growth is far back, it is more difficult to use the shadow method on account of the interference of the orbital margins, and the tumor reaction may be more available in such cases. The shadow method is more easily practised in lightly pigmented eyes, in more prominent eyes, and in the eyes of the aged in whom considerable atrophy of the uveal pigment has taken place. In children, and especially in those who have brown eyes, the method is difficult and the movements of the eye are very embarrassing. Some cases, on account of heavy pigmentation, show little by transillumination, but it is nevertheless true that the majority of all cases show something by the method, and most cases show a great deal.

There seems to be a general idea that the anterior half of the

PLATE I

Transillumination of a Case of Sarcoma of the Choroid. From a patient in the Manhattan Eye, Ear and Throat Hospital.

globe alone is accessible to the transilluminator, but in certain cases it is undoubtedly possible to explore even farther back. According to Stephenson[48], "with Lange's appliance * * * one may often reach considerably beyond the equator," and this is undoubtedly true of Fridenberg's curved tip.

Transillumination of the Cornea and Other Parts of the Eye.

Little additional information is to be gained here besides that which may be obtained by focal illumination. Certain opacities show well and can be localized, but it is important to cut down the current by means of a rheostat so that a feeble light can be secured, otherwise the light will penetrate all tissues alike and no contrasts will be shown. Foreigh bodies show distinctly.

Filtration angle. In this situation we have perhaps the most important application of the transilluminator, certainly the most widely useful. The width of the scleral projection and the anterior limit of the ciliary body can be studied in every case, and information of the greatest importance secured. (See Plate II.) In cases of recent wound, extending into the ciliary body, the transilluminator usually gives us positive information as to the extent of the injury; and in cases of old injury the interruption in the pigment of the ciliary body often shows very clearly. (Plate III.) It is rather surprising that so little stress is laid upon this point, as it is a matter of common experience that the decision in such cases is often difficult and always of importance. The question as to whether or not the ciliary body has been wounded is often a vital one.

Adhesions of the iris at the angle show clearly, as also do small amounts of blood or pus, though it must be remembered that if a large amount of light is used these delicate details do not show so well. For this work a proper rheostat control is absolutely necessary.

Iris. Details in the iris show with great clearness, and it is surprising to note the atrophic spots in an iris which by oblique light appears normal. Very many normal irides in those of advanced age show thin spots in the pigment, through which the light penetrates with the greatest ease. Old spots of atrophy following "gumma" of the iris, lacerations of the iris after cataract extraction, irido-dialysis, and, in fact, any detail in this situation, show very well on account of the contrasts which the pigmented tissue gives. In certain cases, where the iris is very translucent, more delicacy of detail can be gained by cutting down the intensity of the light, as has been mentioned.

Lens. Details in the lens and anterior part of the vitreous show very distinctly, though the regulation of the light is here of the greatest

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[48] Stephenson. Loc. cit., p. 963.

importance. Lens opacities do not offer much obstruction to the light, and indeed a brilliant pupillary illumination can be obtained through a dense mature cataract, a fact of great clinical importance in connection with the "tumor reaction." It is possible to make out certain details in the vitreous, retinal detachment, floating opacities, etc., even where a considerable degree of haziness of the lens is present. Würdemann[49] has made a number of observations in glaucoma with regard to the circumlental space, and concludes that this space, which is usually enlarged during accommodation, may be encroached upon by increase of the lens diameter, advancement in the position of the lens, or thickening of the ciliary processes; and that all these conditions predispose to glaucoma. The present writer, however, has not succeeded in demonstrating the circumlental space, on account of the fact that the margin of the clear lens casts no shadow.*

Ciliary Body and Choroid. One of the most striking features of the shadow method is the presence of the dark ring immediately beyond the limbus, which is the shadow of the ciliary body. (See Plate II.) Its anterior and posterior limits can be distinctly seen, and even the individual processes and the ora serrata can be identified unless the structures are very deeply pigmented. Wounds passing through the ciliary body can be clearly seen, as is shown in Plate III. In tumors of the ciliary region, as Stephenson remarks (loc. cit. p. 964), the method is "quite the most trustworthy means of diagnosis at our disposal." The shadow of the growth may be seen extending from the ciliary body or in the anterior part of the choroid, as the case may be. The color plate (Plate I) was taken from sketches of a case which showed a very doubtful looking retinal detachment by the ophthalmoscope. The diagnosis would have been very uncertain and valuable time would have been lost had transillumination not been available. The appearance left no room for doubt, and after enucleation a large melanotic sarcoma was found springing from the choroid.

Marple[50] reports a very curious occurrence in this connection, which is important to bear in mind. The patient presented by ophthalmoscopic examination what appeared to be a neoplasm, but the full illumination of the Sachs' lamp gave a negative result. When the rheostat was regulated so as to reduce the brightness of the Leber lamp by more than 50 per cent., the tumor reaction was obtained. Marple concludes, "that a negative result with a very powerful light does not mean that there is no neoplasm; it signifies that the latter is non-pigmented, or sparingly pigmented. It is

[49]Würdemann. Diaphanoscopy of the Eye. *Ophthalmology*, Vol. 4. p. 651.

*See Fridenberg's paper: A Study of Transillumination. *Jour. Am. Med. Ass'n*, June 18, 1910, p. 2022; also Jackson's discussion of this paper,, and reference to papers of his in the *Ophthalmic Record*, March, p. 128, 1909. Jackson says: "The statement of Dr. Fridenberg that transillumination gives no indication whatever of the circumlental space is absolutely correct, and it is strange that the idea of such a connection ever gained credence."

[50]Marple. Loco cit.

PLATE II

Transillumination of the Normal Eye. The ciliary body shows as a dark ring, and anteriorly is the Scleral Lip which projects beyond the Plane of the Iris.

PLATE III

Transillumination of an Old Wound of the Ciliary Body. From a patient in the Manhattan Eye, Ear and Throat Hospital.

probable also that a thin flat tumor might escape detection, although I know of no case in point." This observation is of great practical importance, not only in tumor diagnosis but in many other conditions, as has already been mentioned. If the appearances with full illumination are not satisfactory, the light should be cut down by means of the rheostat so as to secure greater contrast, on the same principle that in securing the greatest contrast in photography we use the shortest possible exposure.

Scleral ectasiæ are readily illuminated and, if in the ciliary region, can be studied only with the transilluminator. Foreign bodies, if near enough to the sclera to cast a shadow, can be clearly seen, even if surrounded by exudates, on account of the contrast between the density of the particle and the exudates. Very dense hemorrhages may interrupt the beam of light so as to interfere with the diagnosis, but recent hemorrhages are fairly translucent and difficulty from this cause is not common.

Finally, it is to be remembered that in the ciliary region the ophthalmoscope is useless on account of the fact that the regions are inaccessible to direct examination, while the transilluminator in the great majority of cases meets just this want. Details can be observed here which cannot be studied in any other way. Fridenberg[51] says that by a combination of the transilluminator and the ophthalmoscope,—that is, by using the ophthalmoscope while the transilluminator is placed over the region to be examined,—it is possible "to get a very clear and beautifully brilliant picture of the fundus almost as far forward as the ciliary processes."

It is not too much to say that the routine employment of the transilluminator, in a certain class of cases, should be a part of every thorough examination.

THE ELECTRIC OPHTHALMOSCOPE.

The illuminating power of electricity has been adapted to several of the ordinary instruments of examination. The first to attempt it with the ophthalmoscope was Dennett of New York[52]. He had a small electric light placed in the handle of the ophthalmoscope and, about an inch above it, a convex lens for collecting the light rays. A concave lens was placed just below the mirror so that the rays would be thrown on the mirror properly, but this lens was found to be unnecessary and was later removed. The mirror was placed in front of the aperture, and was plain. At this time it was necessary to use a storage battery, and this was undoubtedly one reason why the instrument was not more universally used. It was very convenient for bedside work. Dennett prefers the ordinary illumination for office work. He says[53], "When

[51]Fridenberg. Loco cit.
[52]Dennett. The Electric Light Ophthalmoscope. *Trans. Am. Ophth. Soc.*, 1885, Vol. 4, p. 156.
[53]Dennett. Personal communication.

the electric light filament is focused on the retina, the illuminated field is so small as to be unsatisfactory. This condition is remedied in part by putting the lamp so much out of focus that the lighted part of the patient's retina is an enlarged and much distorted image of the filament, with such an approach to a uniform illumination as can be obtained in that way. When the pupil is of good size and the lamp is pushed up pretty near the mirror the resulting illumination is sometimes very satisfactory, but for getting the relative value of many observations made at different times through pupils of different sizes, I like the old argand burner best. When the flame of the argand burner is

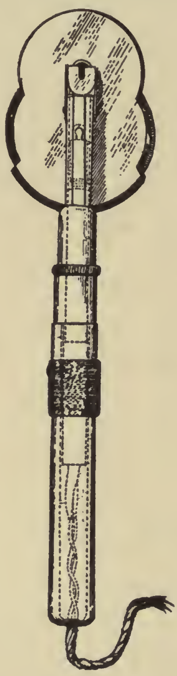

Fig. 92.
Marple's Electric Ophthalmoscope.

focused accurately on the retina, one has both theoretically and practically a satisfactory large surface of retina uniformly illuminated."

The De Zeng ophthalmoscope was constructed on similar lines. A tiny incandescent light was placed in the handle, about an inch from the level of the aperture, from which the wires ran out at the end of the handle. The disc containing the lenses was placed at one side of the handle, which latter had a lense in the end so as to cast as strong as possible a light upward, where it was received by a mirror set at an angle of 45°, through which the opening for the observer was placed.

Marple[54] modified Dennett's ophthalmoscope by using a U-shaped mirror and adding a slide attachment to the light so that it could be moved up and down and the distance of the light from the fundus to be examined could be altered at the observer's convenience (Figure 92). These points are best explained in the writer's own words.

Marple says: "The difficulty I found in using Dennett's instrument,—and this is true also of De Zeng's,—was that I did not seem able to direct the illumination always to that part of the fundus at which I wanted to look. Especially was this true if I endeavored to examine anything at the lower part of the fundus. I could always observe a horizontal line of shadow beyond which I could not see, turn the instrument howsoever I might. For example, if I wanted to investigate the periphery of the lens below, to ascertain as to its transparency, I would invariably find this region in total shadow. As I discovered, however, that if I held the ophthalmoscope with the handle directed horizontally to the side of the patient, then I could illuminate the lower part of the fundus all right. It was evident that the trouble was that the whole mirror was entirely below the line of vision when using it. I then began experimenting with various forms of mirror, the first shape being one with a round aperture, like the ordinary ophthalmoscope. But so much light was reflected into the observer's eye by such a mirror of the ordinary thickness that a very unsatisfactory view of the fundus was obtained." Marple next tried a very thin mirror but could see no difference. "As the reflection was entirely from the upper edge of the aperture, I next cut this part of the mirror away, using a U-shaped piece of glass. With this there was no annoying reflection, and, to my great satisfaction, I now found that the whole fundus was illuminated, and also that I could control my illumination completely, investigating the lower part of the fundus as well as any other. To satisfy myself, I covered the two arms with blackened paper, and again found the lower part of the fundus in darkness. I then uncovered more and more of the two arms until I found just the length which gave me what I wanted, and the mirror seen in the instrument shown here is the one which gives me the best results." With regard to the other modification, Marple says: "It occurred to me that it would be an improvement if the position of the lamp could be controlled by the examiner while using the instrument. So I accordingly had an arm carried down with a small roughened knob at the end, by which the observer, when examining a patient, can slide the lamp up and down, and thus get just the kind of light which brings out what he is looking for."

This instrument can be attached to the street current, with the interposition of a rheostat, or to a dry-cell battery, thus making it very convenient for bedside work.

De Zeng has recently devised, after the suggestion of G. S. Crampton, a method of illuminating the electric ophthalmoscope which does away with a special battery,—in which, indeed, the battery is carried in the handle of the ophthalmoscope. This instrument is shown in Fig. 93. A Tungsten lamp of 2½ volts is used, requiring but one-sixth of an amphere. Two small dry cells, of the best quality obtainable, are placed in the handle, and it is claimed by the manufacturer that these cells will give as much service as the old six-cell pocket battery.

Advantages of the Electric Ophthalmoscope.

The advantages of the electric ophthalmoscope are: First, the ease with which the illumination is managed. In the ordinary reflecting ophthalmoscope the angles are difficult to master and the red reflex of

[54] Marple. An Improved Electric Ophthalmoscope. *Trans. Am. Ophth. Soc.*, 1906, Vol. 2, p. 225.

the fundus disappears with the slightest false move on the observer's part. It is necessary constantly to vary the angle of the instrument, the position of the observer's head, the position of the patient's eye, and the distance of the source of light. Beginners find these points very difficult, and experience is needed to overcome them. With the electric ophthalmoscope, the illumination takes care of itself. A second advantage is that there is no bright light glaring into the eye of the

Fig. 93.

De Zeng's Electric Ophthalmoscope (latest model). The battery is carried in the handle.

observer. In using the ophthalmoscope it is necessary for the observer to relax perfectly his own accommodation, as is well known. This is much easier to do if we keep the fellow eye open, but many find the glare of the light so embarrassing that it distracts their attention and they are forced to close the fellow eye. This is particularly the case with beginners or with those who do not use the instrument constantly,

but it is also true of certain more experienced ophthalmologists. With the electric ophthalmoscope the fellow eye of the observer can always be kept open. Third, there being no question of an angle to the rays of light, it is possible to get much closer to the pupil, and a better view is obtained through a very small pupil, and a larger field through any pupil. Fourth, there is not nearly the extensive loss of light with the electric that there is with the old ophthalmoscope, and the image is therefore brighter. In fact, it is claimed—and the claim seems reason-

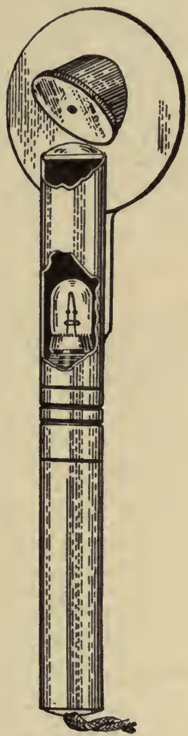

Fig. 94.
De Zeng's Electric Retinoscope.

able—that there is very little loss of light. Finally, the ease with which the instrument is used in any position makes it vastly superior for fundus examination of those who are ill in bed and unable to sit up in the position usually required.

There is a small disadvantage in Marple's mirror, in the gap at the top, which leaves a small part of the fundus slightly shadowed, but this is unimportant as a slight turn in the instrument brings this part into view.

In the indirect method, the electric ophthalmoscope works as satis-

factorily as in the direct. The ophthalmoscope is held at the usual distance and the light is pushed up until the image of the flame appears on the patient's forehead as a bar of light. Then the convex lens is interposed and a good image of the fundus is obtained.

De Zeng has devised a *retinoscope* which is based on the same idea and is shown in accompanying figure. A plane mirror is used, and the light is placed in the handle in the same manner as in the ophthalmoscope.

ELECTRIC HEAD MIRRORS.

These instruments have been made in a variety of styles, but are very simple in design. One of the best is the Klar-Alexander mirror. This consists of a concave mirror with a small electric light on a supporter in the center of the concavity. Two holes are cut in the sides of the mirror so that the observer's eyes follow the same line as the beam of light. A very brilliant and satisfactory illumination is secured.

Ophthalmo-Diaphanoscope.

Dr. Carl Hertzell[55] of Berlin, has devised an instrument which he calls an "ophthalmo-diaphanoscope," and which involves some new principles in ocular examination. It consists of an 80-candle power electric light which is enclosed in a tube and surrounded by a water jacket to avoid heating. The light, by an arrangement of reflecting surfaces at the end of the tube, is thrown upward and backward toward the other end of the instrument. This instrument is placed in the mouth as far back as possible, so as to throw the light back of the soft palate. A black face mask with openings for the patient's eyes is used. An entirely dark room is, of course, necessary. When the light is in position and the current turned on, the observer simply approaches as closely as possible to the patient's eyes and can see "without any practice" the details of the fundus. In myopic cases a concave lens must be interposed. Dilatation of the pupil is said not to be necessary. The instrument also has an attachment by which transillumination from without can be done and which is similar to the glass cone of the Sachs transilluminator.

The Electric Spud and Knife Needle.

A very ingenious and useful instrument has recently been devised by two independent observers, almost at the same time, for removing foreign bodies from the cornea and for certain other uses. The first to be published was the one of R. L. Carson[56] on May 9, 1908. It consists

[55]Hertzell. *Scientific American*, Nov 6, 1909.
[56]Carson. An Illuminated Spud and Knife Needle. *Jour. of Am. Med. Ass'n*, Vol. 50, p. 1523, 1908.

of a handle five inches in length through which run the wires to a tiny incandescent condensing lamp at its end. A short distance from the end of the handle is a clamp into which is fastened a spud of sufficient length and bent at such an angle as to bring its tip into the center of the circle of light thrown by the lamp. The manufacturers later modified this form by putting the lamp on the arm, and the spud on the end of the handle, where it was fixed by a screw, so that the inconvenience of working with an angular instrument was eliminated. Albert C. Snell[57] described a similar instrument, which is shown herewith. These instruments can be attached to a small dry-cell battery or to the lighting current controlled by a rheostat. The advantages are so obvious as scarcely to need enumeration. Everyone is familiar with the difficulties and inconveniences involved in holding the light, focusing it properly on the cornea, separating the patient's lids, and holding the instrument in the removal of foreign bodies from the cornea, with only two hands. These convenient little appliances do away with a great deal of the dif-

Fig. 95.
Snell's Electric Spud and Knife Needle.

ficulty, and enable the surgeon to hold the lids with the fingers of one hand while the foreign body is removed by the spud held in the other. Two forms of spud are supplied—one sharp, the other blunt—which can be taken from the handle and sterilized. In fact, the whole handle may be boiled if necessary.

Both writers claim that the instrument can be used for needling after cataract extraction, and that it is just as convenient as in the removal of foreign bodies.

THE SIDEROSCOPE.

Prior to the discovery of the Roentgen rays, the diagnosis of the presence of a particle of iron or steel, or other foreign substance, within the globe was often a very difficult matter. As the majority of foreign bodies that enter the globe are of magnetizable material, the magnetic needle has been used in a variety of ways as an "indicator." The first to use the magnetic needle for this purpose was Thomas R. Pooley[58],

[57]Snell. An Illuminated Spud. *Ophthalmology*, July, 1908, Vol. 4, p. 643.

[58]Pooley. On the Detection of the Presence and Location of Steel and Iron Foreign Bodies in the Eye by the Indication of the Magnetic Needle. *Archives of Ophth.*, 1880, Vol. 9, p. 255; also the sideroscope, N. Y. *Med. Jour.*, Mar. 8, 1902.

who performed numerous experiments and demonstrated the delicacy of the method. He tabulated the deflection of the needle by particles of different sizes at various distances from the needle, both magnetized and unmagnetized. This was the first use of the method in connection with the eye, although it had been used in general surgery. The idea was

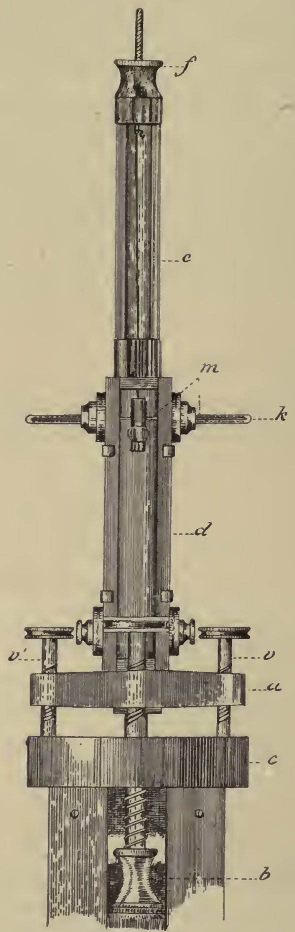

Fig. 96.
The Sideroscope of Asmus.

later elaborated by Asmus[59], who constructed an instrument containing a magnetic needle suspended by a silk thread in a glass tube, as shown in Fig. 96. This apparatus consists of a box of wood 15 cm. high (d), closed before and behind by a plate of glass sliding in a groove.

[59]Asmus. Das Sideroskop. *Archiv. f. Ophth.*, 1894, Vol. 1, p. 280.

This box stands upon a disc of iron (a), which is levelled by three screws (v), thus allowing the instrument to be made perfectly vertical. These screws rest upon a second disc (c), which is fixed to a north and south wall. A fixation screw (b), maintains the position. Above the box of wood is a tube of glass (e), and in this tube hangs the silk thread which holds the magnetic needle. This thread is attached to a regulating screw (f), which allows one to raise and lower the needle, and also to turn it so that it may hang free. At the lower end of the thread is hung an aluminum tube which supports a small mirror and the magnetic needle (m). The needle is 11 cm. long and extends from the box of wood for a distance of 4 cm. on each side. Each end of the needle is enclosed in a tube of glass (k) which is 6 mm. in diameter.

The Magnetometer of Léon Gérard.

At about the same time as the publication of the preceding instrument, Gallemaerts[60] demonstrated the magnetometer of Gérard (Fig. 97). This consists of a base with three levelling screws (c) supporting a horizontal bar on one end of which is the apparatus containing the magnetic indicator (g) and on the other the scale and telescope for noting accurately the deflections of the indicator. The horizontal bar (d), is of copper and 40 cm. in length. The indicator is composed of six little bar magnets, each of which is 6 mm. long, 2 mm. wide, and 1 mm. thick, and is suspended by a thread of silk which extends from a small button through a glass tube (a), and is enclosed in a cylindrical compartment about the size of the eyeball, closed before and behind with glass. The button at the top of the tube allows one to raise and lower the indicator so that it hangs free. One "window" of the compartment which contains the indicator is concave so that the eye to be examined may be brought as closely as possible to the magnetized indicator. On one side of the indicator is a small concave reflecting mirror, 6 mm. in diameter. The telescope points directly at the mirror of the indicator and through it can be observed the reflection of the rule which is placed over the telescope. The telescope contains cross-threads for centering, and the slightest deflection of the indicator can be accurately estimated. Upon the horizontal bar (d) is placed a small magnet (j), 5 cm. in length, which permits one to modify the direction of the indicator by approaching or withdrawing it, thus augmenting or diminishing the indicator's sensibility.

Hirschberg's Sideroscope.

Hirschberg[61] has modified the sideroscope of Asmus by adding an

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[60]Gallemaerts. Sur la recherche des corps étrangers magnétiques ayant perforé le globe oculaire, avec démonstration du magnétomètre de Gérard. *Bull et Mèm. de la Soc. Franc. d'Ophtal.*, 1894, Vol. 12, p. 143.

[61]Hirschberg. Vereinfachtes Sideroskop. *Centralbl. f. Augenhlk.*, 1899, Vol. 23, p. 285.

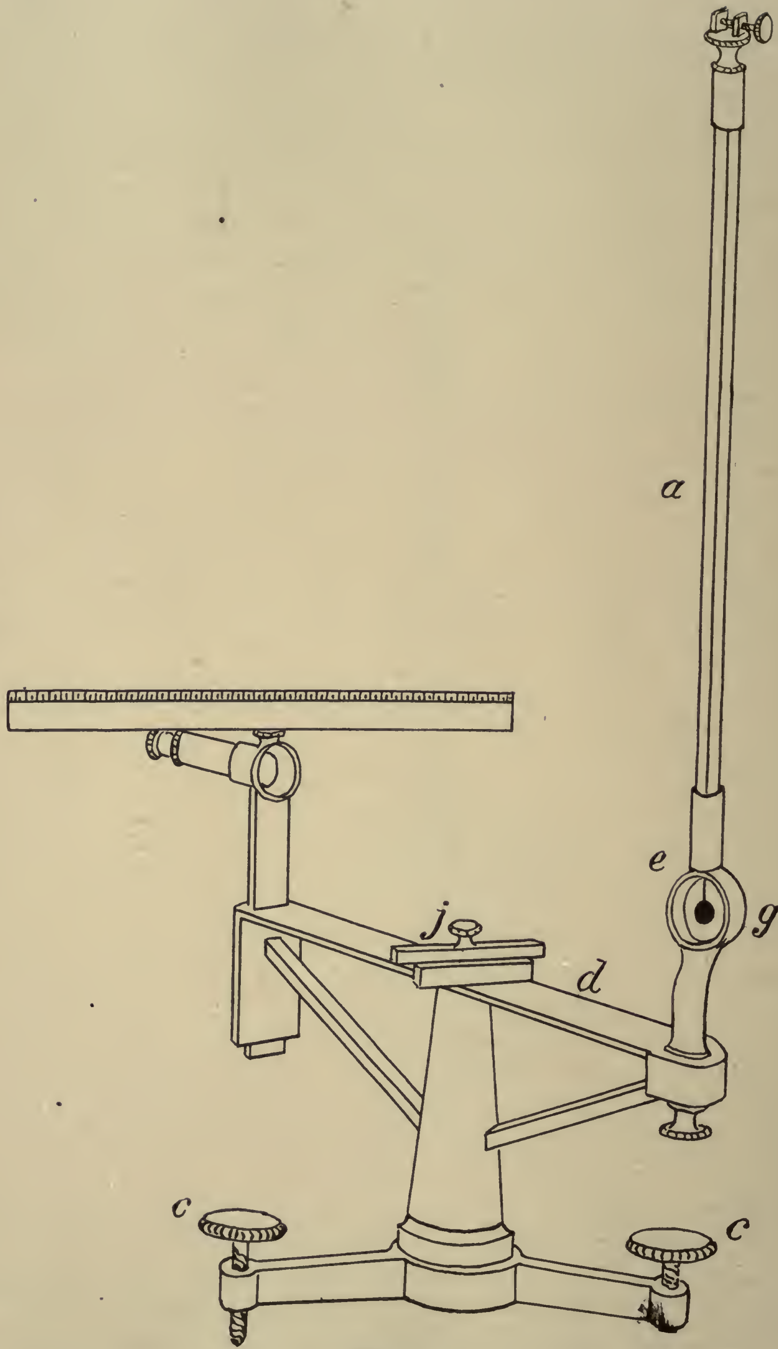

Fig. 97.
The Magnetometer of Gérard.

apparatus which throws a beam of light on the mirror, which is then reflected to a graduated scale (see figure). The instrument is first regulated so that the beam falls on the zero of the scale, then the eye of the patient is approached to the glass tube containing the magnetic needle. Should a chip of iron or steel be present in the eye, the spot of

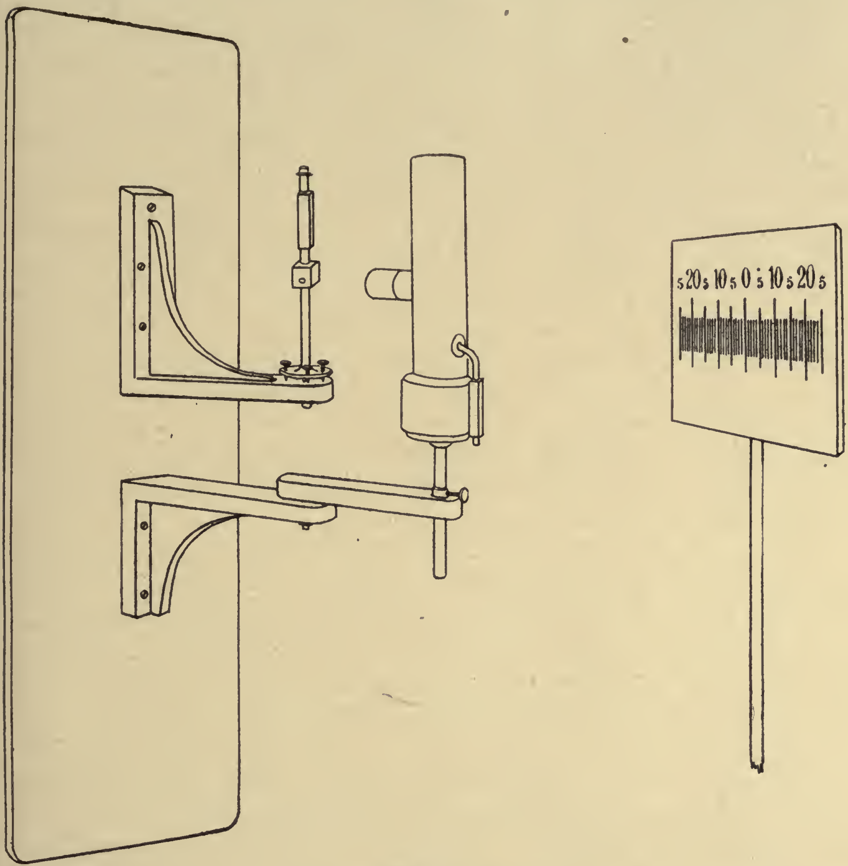

Fig. 98.
Hirschberg's Sideroscope.

light will travel along the scale. The larger the particle the greater will be the extent of the deviation.

Janssen's Siderophone.

Martin Janssen[62] of Stockholm, has constructed a very ingenious instrument which he calls the siderophone. It is composed of a magnet with an interrupter which is attached to the telephone. On bringing

[62]Janssen. See Béal. *Corps étrangers magnétiques oculaires, et leur extraction*, Paris, 1908, p. 23.

the apparatus near to an eye containing a particle of iron or steel, the telephone rings slightly.

Advantages and Limitations of the Sideroscope.

All these instruments are of extreme delicacy, and are capable of giving very good results, but the use for them has to a great extent passed away since the introduction of the Roentgen rays, which determine the presence, location and size of the foreign body at one and the same time. In using them, it is necessary to be sure that neither the patient nor the examiner has any magnetizable metal about the person—keys, penknives, etc. The instruments are so sensitive that the needle or indicator can be deflected by particles of iron or steel in the hair, and if the examining room is within a short distance of an electric car line or other powerful electric current they are very difficult to manage. (Asmus[63]). In using them, the injured eye is brought as near as possible to the magnetic needle or indicator, and it is noted, by the mirror or the telescope, as the case may be, whether a deflection has occurred. At times the indicator remains immovable, even when the foreign body is present, and in this case the foreign body must be magnetized by approaching an electro-magnet to the eye, after which a fresh attempt may be made. If still no deflection occurs, there is probably no magnetic particle present, although this, of course, does not exclude particles of other substances than iron or steel.

The sideroscope of Asmus, on account of its peculiar structure, is also of value in approximately localizing the foreign body. By approaching successively different parts of the eye to the needle and noting the spot of greatest deflection, and also the direction of the deflection, a fair idea of the situation of the particle may be obtained, if it lies in the ciliary region, or anterior. Where the particle lies in the posterior segment, the angles made by the different positions of the needle are not so great and the localization is rather vague—as indeed it is in any case compared with the results of localization by the X-rays. The amount and strength of the deflection leads one to infer something as to the size of the particle, a stronger deflection meaning a relatively larger particle. However, it must be remembered that in the absence of precise knowledge as to the distance between the needle and the particle, our inferences are bound to be only roughly approximative. If the deflection is very strong, it is difficult to localize the particle on account of the erratic movements of the needle, and it is best, under these circumstances, to render it less sensitive by placing a second magnetic needle parallel to the needle of the instrument, but in such a manner that

[63]Asmus. Meine Erfahrungen mit dem Sideroskop seit Erführung der elektrischen Strassenbahn in Düsseldorf *Klin. Monatsbl. f. Augenhlk.*, 1901, Vol. 39, p. 423.

the north pole of the second is opposite to the south pole of the first. The instrument is then readjusted, and, as the needle is much restrained in its action by the presence of the other, when the patient is brought near the deflection is much less marked and the localization can be much better done. (Béal loco cit. p. 27).

The advocates of the sideroscope and those who have used it enough to master its technical difficulties—which are not slight—are enthusiastic over its powers, and there is no question but that it has been of great service in the past. Gruening[64] says that "in 25 successive cases observed at the University Eye Clinic in Breslau in 1893 and 1894, fragments of iron or steel were detected by this instrument." Asmus[65] still writes enthusiastically of it and reports a case in which the sideroscope was successful after the X-rays and Haab magnet had failed. However, the localization of foreign bodies by the X-ray is so far superior in point of accuracy that it is hardly conceivable that any one should of choice select the less perfect method at the present time. The sideroscope has only one advantage over the X-ray—that of time—and it is a great question whether the thirty or forty minutes necessary for an accurate skiagraphic examination are to be weighed in the balance. Moreover, in large institutions, or in offices in large cities, the electrical disturbances are so great that the delicacy of the instrument is seriously hampered—although Asmus[66] reports good results with Koster's device for obviating these disturbances. It is possible that in smaller places where the disturbances are not so great and where the X-ray apparatus is not obtainable the sideroscope may still be used with advantage.

THE X-RAYS. ROENTGEN RAYS.

Since their discovery by Professor Roentgen in 1895, the X-rays have taken a position of ever increasing importance in all branches of surgery, to which ophthalmology has been no exception. They are formed by the discharge of a high tension electric current through a vacuum, in suitably prepared tubes, and are generated by the cathode rays impinging upon a solid object, the anode, from which latter point they are given forth in all directions. These rays produce shadows, cause fluorescence, and have a chemical action on a photographic film. They penetrate, in different degrees, substances which are opaque to light, which property gives them their peculiar value in the localization of foreign bodies in the eye, and have a further marked thera-

[64]Gruening. *System of Diseases of the Eye.* Norris and Oliver, 1898, Vol. 3, p. 709.

[65]Asmus. *Klin. Monatsbl, f. Augenhlk,* 1908, p. 262.

[66]Asmus. Ibid.

peutic effect on certain morbid processes, the exact nature of which is not yet fully understood.[67]

Equipment Required for Developing the X-Rays.

The various parts of an X-ray equipment are the generating apparatus, consisting of an induction coil, or a static machine, or high frequency apparatus, with a vacuum tube and its holder; and the receiving screen, which is either a fluorescent screen (fluoroscope) or a photographic plate.

The Static Machine, which is too well known to require special description, is in many respects convenient, but requires to be run by an electric or water motor and is therefore more troublesome than the induction coil. The tubes excited by it are not used up so quickly as are those excited by a coil.

The Induction Coil, or *High Frequency Apparatus* may be run by a current from a primary battery, by a storage battery charged by gravity cells or from the street main, by a dynamo which generates a continuous or alternating current of high or low voltage, or directly from the street main with a continuous or alternating current. At the Manhattan Eye, Ear and Throat Hospital, the induction coil of the Ruhmkorff type is used, with a continuous current from the hospital dynamo of 110 volts.

The Vacuum Tube, which is perhaps the most important part of the equipment, and certainly the most difficult to keep in proper condition, consists of a glass bulb about 10 cm. in diameter, in the interior of which are two terminals—one of aluminum, the cathode; and one of copper faced with platinum, the anode. Sometimes a third is added—the anti-cathode—which is usually made of platinum alloyed with iridium. A palladium wire connected with the exterior is also present, and is protected by a glass cap. This wire is used for lowering the vacuum in the tube, should this become too high. The glass cap is removed and the wire is heated by means of an alcohol flame, thus generating a certain amount of gas in the interior of the tube. The rays require only a certain amount of gas in the tube for their proper transmission, and if there is too much the tube is said to be "low" and the rays are lacking in penetrative power. The low tube is more bluish in color as the rays are passed through. It is made higher by passing a reverse current through the anode and anti-cathode. On the other hand, if the vacuum becomes too rare, the tube is said to be too "high" or "hard," and there is a greater resistance to the passage of the rays, which, as a consequence, have less strength and penetrating power. This is shown by the low reading on the miliam-meter and the fact that the

[67]F. H. Williams. *The Roentgen Rays in Medicine and Surgery,* 3rd Ed., N. Y., 1903.

spark jumps across the spark-gap (rather than to go by its usual route), even if the length of the spark gap be very much increased.

A variety of good tubes are manufactured at the present time, and it is hardly desirable in the present connection to describe them in detail, but it may be said that one of the prime requisites is to have a sufficient number of tubes so that each may be allowed a period of quiescence. The vacuum tube is a sensitive affair, and while each one should receive enough use to keep it in condition, any attempt to exact more service from it is certain to result in hitches and difficulties, and poor penetration and poor results. At times the tube will go higher and higher as it is used, the miliam-meter will give a lower and lower reading, and finally discharge occurs around the external surface of the tube. Under these circumstances it is better to resort to another tube and allow the refractory one to rest for a period of several days. A very useful device is a wire "regulator" with two arms. This is applied to the tube so as to cause a sparking, which gives off a certain amount of heat and lowers the vacuum.

The penetration of the tube may be measured by a little disc of aluminum with a silver center, known to manufacturers as a "Penetrometer." This has little blocks of different thicknesses, numbered from one to twelve, around the circumference, and when viewed with the fluoroscope some idea can be gained of the power of the tube by comparing the blocks with the central disc of silver which is taken as a standard. Thus, if the central disc is the same shade as the block marked "7," we say that the tube has a penetration of seven. For fluoroscopic work, it is scarcely possible to have too great a penetration, but for photographic work the usual laws of the action of light obtain and too great a penetration results in reduction of the photographic plate everywhere and less contrast. The photographic principle that it is easier to work with a moderate light and a long exposure than with a strong light and a short exposure holds good here, for with a short exposure any error in time is *proportionately* greater. For thick objects, as in the photography of the shadow of a foreign body in the eye, a penetration of about seven is best. Usually, however, the experienced operator learns to judge of the penetrative power of the tube by the yellowish-green "fluorescent" shade which is present when the tube is working properly.

The Tube Holder, which is shown in Fig. 102, is composed of an upright standard with an adjustable arm which grasps the tube between curved felt-covered holders. Two side arms are added for the purpose of holding the wires and of keeping them away from the tube to avoid cross-circuiting. In the holder which is used for the localization of foreign bodies in the eye, it is essential that a graduated scale should

be added and that the arm allow of a movement of the tube along measured lines, without lateral displacement, which would lead to error. In the Brickner holder there are two separate scales, one on the upright to measure the vertical displacement, the other on the arm, to measure the lateral displacement. The tube may thus be displaced up and down, or sideways, by turning the large handscrews, but is always in the same plane.

The Fluoroscope. This instrument consists of a pyramidal box with an opening at one end which is so shaped as to fit closely around the eyes of the observer and exclude the light in the room, while the other end is closed by the fluorescent screen, which is made by coating one side of a piece of cardboard with crystals of tungstate of calcium or with platino-cyanide of barium. The X-rays have the power of rendering these chemicals fluorescent in greater or less degree as they are interrupted in their passage to the screen, so that if an object be held between the rays and the screen a shadow will be formed which shows certain details very well. For flat, thin objects the fluorescent screen is very useful, but for the delicate "detail" work required in the situation of the eye, it is far inferior to the photographic plate.

The Photographic Plate should be one of thin emulsion, *i. e.,* a quick plate, and should not be too old. Almost any reliable plate answers well for this purpose—Lumiére, Carbutt, Seed, Cramer, etc. They are best enclosed first in a black envelope and then in an orange one, so that no holder is necessary. In using such a plate, it is simply placed in position beside or under the head and the light-proof envelopes are readily penetrated by the ray. While in the room with the machine, they should be kept in a box lined with sheet lead, 3 mm. thick, and only brought out when the exposure is to be made. It is particularly important that these delicate plates be kept free from moisture, and if it is necessary to make the exposure with the patient's face or any part of the skin pressing on the envelope, a thin sheet of rubber should be interposed so that the perspiration will not penetrate the envelopes.

Developing. In the development of the plate the ordinary rules of photography are to be followed. It is always best, in order to ensure delicacy of detail, to develop the plate rather slowly and to allow the image to come up with the least possible forcing. Hydroquinone or Metol-hydro give good results and are easily handled. The temperature of the developer should be about 70° F., although this need not be exact. If the time of the exposure has been correct, any standard mixture of the above solutions will give good results, for in X-ray work as in ordinary photography, it is easy to develop a correctly exposed plate but very difficult to secure equally good results with an incorrectly exposed one. A 10 per cent solution of bromide of potassium should

always be kept on hand, so that if the plate starts to develop too rapidly, in the case of over-exposure, a few drops may be added and the image restrained. This procedure will give a certain amount of contrast to what would otherwise be a flat weak plate. If the plate be under-exposed, which is shown by the image coming up very slowly, the only thing to be done is to continue the development in a very feeble light for a long period, so as to force the image up as much as possible. Strengthening the developer is seldom effective.

Printing. Occasionally it is desired to print from the negative, and when this is the case the old silver print or glossy velox gives the best results. It must not be forgotten, however, that no printing process reproduces all the details of the negative without some loss, and the transparent negative gives the best image from which to interpret the details; so that for practical purposes printing is unnecessary. Moreover, in the print, the situation of greatest tissue density, which is usually the most interesting part of the picture, is the darkest, while in the negative it is the lightest—a point which has obvious advantages. A transparency loses less detail than a print, but is open to the same objections. The best plan is to use the direct negative for the examination, illuminated by a box with a ground glass plate in the front and an electric light within, the intensity of which can be controlled by a rheostat. Certain "thin" negatives show best with feeble illumination, so the rheostat control is necessary.

Uses of the X-Ray.

In the present consideration the X-rays have three principal uses:

1st. In the *treatment* of various ocular lesions.

2nd. In the *diagnosis* of sinus disease or tumors.

3rd. In the *localization* of foreign bodies in the globe or orbit.

Treatment of Ocular Disease by the X-rays. A large number of diseases of the eye and its adnexa have been treated by exposure to the rays, as epithelioma, lupus, trachoma, sarcoma, corneal scars, detachment of the retina, cataract, optic atrophy, etc. Much of this work has been directed by the suggestions of experience in X-ray burns and has been along logical lines, and has been attended by a marked degree of success. In other conditions, the treatment has been purely experimental, and evidence is wanting to establish its value. It may be said in general that the most favorable results have been obtained in superficial malignant processes—of which epithelioma is the best instance—in superficial ulcerative processes, as in lupus, and in certain milder proliferations—as in keloid, papilloma and trachoma. In all these, the action is probably by the production of inflammation with breaking up of the tissues exposed, though a variety of opinions are held and the

question is by no means settled. The treatment is most apt to be successful where the condition is superficial and the rays can be directly applied to the diseased area. A special form of tube should be used, which is usually long and narrow and made of glass which contains a large proportion of lead, with a small area of ordinary glass in the end, so that the operator and the other parts of the patient's skin do not receive the rays. These small tubes may be applied directly to the area, or a large tube may be placed 30 to 50 cm. away from the patient. If a large tube is used, the area surrounding the area of disease should be covered by a lead plate so as to avoid burning the tissues. The first exposure should be limited to five minutes, though, if no bad symptoms occur, this may be gradually lengthened to ten or even fifteen minutes. The treatments should not be given more frequently than three times a week, and if there is any indication of especial susceptibility on the patient's part, it is better to extend the time in order to avoid a cumulative effect. While burns from single exposures are very rare, in repeated exposures in the course of treatment, burns are very apt to occur unless the case is handled with caution. The skin should be carefully watched for any redness, "shiny" appearance, or pigmentation, and any suspicious appearance should be the signal for the cessation of treatment until the symptoms subside—unless, indeed, in the operator's opinion, the treatment should be pushed, even at some risk. Keinbock[68] describes four degrees of acute dermatitis from this cause. The first appears twelve to sixteen days after exposure, as a rule. The hair loosens and falls out, leaving the skin smooth and bald. Some months—perhaps three or four—after the onset, complete return to the normal takes place. In cases of the second degree, the latent period is shorter. There is slight swelling with hyperemia. The skin becomes light red, then dark red, and finally scales off. Complete recovery ultimately takes place, though some pigmentation may remain. In the third degree, blisters or even extensive exfoliation may occur; while in the fourth degree there is dry necrosis of the tissues. Recovery takes place only with the formation of scar tissue in the third and fourth degrees, and is sometimes extremely protracted.

The literature of the subject is very large and is being constantly increased. W. A. Pusey, of Chicago, has written numerous articles, and has given some very interesting results.[69] He observed 111 cases of epithelioma after three years had elapsed, and records 80 successful cases, 2 cases "practically successful," 17 distinctly benefited, and 12

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[68]Keinbock. Hautveränderungen durch Roentgenbestrahlung bei Mensch und Thier, *Wiener Med. Presse*, 1901, p. 874.

[69]Pusey. The Roentgen Ray in Epithelioma. *Jour Am. Med. Ass'n*, 1908, Vol. 50, p. 100.

failures. Sweet[70] has reported some interesting observations. Ring[71] has contributed a very valuable resumé of what has been done up to 1906, while Williams[72] gives a general bibliography of the articles published prior to January 1st, 1903.

The Diagnosis of Sinus Disease or Tumors by Means of the X-rays.

Recently numerous attempts have been made to utilize the X-rays in the diagnosis of purulent collections in the frontal, ethmoidal, and other sinuses[73], and for the purpose of locating and aiding in the diagnosis of growths in and near the eye and orbit. This work presents peculiar difficulties in that the contrast in the density of the tissues concerned is not great, a great thickness of tissue has to be penetrated, and, as a rule, a "perspective" view is given which is difficult to interpret on account of the "forest" of bony structures seen. Views of the frontal sinuses and surrounding parts are best taken with the plate on the table, the patient lying face down upon the plate and the tube at a distance of 40 cm. above the back of the head. In this way the shadows of the anterior part of the orbits show most strongly, while the structures farther back are less definite and "shade off" so as to interfere as little as possible with the picture. The tube is placed at the distance mentioned for the reason that the farther away it is placed the more distinct will be the shadows cast by objects close to the plate. Of course the time of exposure must be increased in proportion as the tube is withdrawn from the head. For negatives of this character, an exposure of 30 seconds or more is required. The chief point in the diagnosis of sinus disease is the difference in density betwen the affected side and the other, which is assumed to be normal, and this point is undoubtedly of great value. It must be remembered, however, that all that can be safely assumed, when one side is darker, is that there is a difference in *density* between the two sides; the *cause* of this difference must be inferred from other symptoms. On the other hand, if both sides are equally clear, it is highly probable that the sinuses are free of pus or other dense fluid.

In the diagnosis of growths of the orbit or its neighborhood, it is best to take the negative at an angle—either from the side, obliquely

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[70]Sweet. The Treatment of Epithelioma of the Eyelids by the X-rays. *Amer. Medicine*, Dec. 13, 1902, Vol 4, p 935; also *Trans. Am. Ophth. Soc.*, Vol. 9, p. 550.

[71]Ring. The Value of X-rays in Ocular Therapeutics. *Trans. Sec. on Ophth. Am. Med. Ass'n*, 1906. p. 326.

[72]Williams. Ibid., p. 732.

[73]See papers by Langworthy: The X-ray in Rhinology, *Laryngoscope*, October, 1907; The Value of the Routine Use of the X-ray in Orbital Affections arising from Accessory Sinus Disease, *Am. Jour. of Ophth.*, April, 1907; and The Use of the X-ray in Accessory Sinus Disease, *Iowa Med. Jour.*, Oct. 15, 1907. The first of these gives a bibliography of nineteen papers.

forward, or from behind forward—so as to avoid a great thickness of tissue and its resulting confusion. Even under the most favorable circumstances, however, the results are not always satisfactory, and the plates must be interpreted by an experienced eye to be of any value. The density of orbital sarcomata and other growths is so little greater than the surrounding tissue, and the shadow is so masked by the bony structures that even when the negative is of the highest order of excellence it is difficult to be positive as to the significance of the appearances. It is best to adjust the tube at such an angle that as clear a space as possible is obtained, and then to give as short an exposure as is possible, to secure the requisite penetration. Osteomata, or variations in the osseous structure, of course can be shown well.

The Localization of Foreign Bodies in the Globe or Orbit.

The localization of particles of metal or other foreign material in the interior of the globe or orbit may be said to be the most important use of the X-rays in ophthalmology today. Not only are we able to diagnose the presence of a foreign body, but we are able to determine its size, and, with a great degree of accuracy, its position. The information obtained by the X-ray is of the greatest value in enabling the surgeon to choose the proper method of operation and to avoid the operative complications which are not infrequently the cause of disaster. The X-ray very rarely fails to give us a satisfactory diagnosis, while the other instruments for the diagnosis of foreign bodies in the globe have all marked disadvantages. The ophthalmoscope is frequently limited in its value on account of the haziness of the media from hemorrhage, swollen lens substance, etc. The so-called "Giant" magnets which have been used for this purpose should never be so employed. Not knowing the size of the foreign body, or being able only to infer its size from the appearances of the wound, and knowing nothing of its situation, to apply a powerful magnet to the eye is at the present time the worst possible practice. If the particle be large it may be suddenly and violently dragged forward and do serious damage to the tissues of the eye; and while foreign particles in the vitreous usually sink to the lower part, they do not always do so, and it is important to know the exact situation so as to be able to lead the foreign body in the proper direction. Besides these disadvantages the magnet at times utterly fails to give any reaction, either because the particle is too small or too far away from the point, or because the particle is enclosed in an envelope of connective tissue, or finally, because the particle is of some non-magnetizable material. The sideroscope is only of use in the case of magnetizable foreign bodies, and while localization may be obtained it is only approximate. Moreover, the instrument is extremely delicate, is difficult to manage, and is readily disturbed by extraneous influences,

as has been before stated. If the sideroscope is not affected, it is probable that the eye does not contain a magnetizable foreign body, while the negative diagnosis in the case of the magnet is of uncertain value.

The X-ray, however, rarely leads to a wrong diagnosis, if a photographic negative is used. Except in the case of a few substances—not commonly found in penetrating wounds of the eye—a clear, distinct shadow is cast. If no shadow is cast, there is almost certainly no foreign body present. It is possible that a very thin scale of metal may be overlooked, especially if it be situated in dense bony shadow, but even this is rare. Sweet[74] reports two cases of failure from this cause in his series of 702 cases, of which 395 contained a foreign body. Given a good negative, the X-ray today is the method of all others for the diagnosis and localization of foreign bodies in the globe, and the results of localization are accurate to a surprising degree. The table, given below, shows the relative transparency of various substances to the rays.

TRANSPARENCY OF VARIOUS SUBSTANCES FOR ROENTGEN RAYS:
(Batelli and Garbasso)[75] Water = 1.

Material.	Sp. Gr.	Transparency.	Material.	Sp. Gr.	Transparency.
Pine wood	0.56	2.21	Tin	7.28	0.118
Walnut	0.66	1.50	Zinc	7.20	0.116
Paraffin	0.874	1.12	Iron	7.87	0.101
Rubber	0.93	1.10	Nickel	8.67	0.095
Wax	0.97	1.10	Brass	8.70	0.093
Stearine	0.97	0.94	Cadmium	8.69	0.90
Cardboard		0.80	Copper	8.96	0.084
Ebonite	1.14	0.80	Bismuth	9.82	0.075
Wool cloth		0.76	Silver	10.50	0.070
Celluloid		0.76	Lead	11.38	0.055
Whalebone		0.74	Palladium	11.30	0.053
Silk		0.74	Mercury	13.56	0.044
Cotton		0.70	Gold	19.36	0.030
Charcoal		0.63	Platinum	22.07	0.020
Starch		0.60	Ether	0.713	1.37
Sugar	1.61	0.60	Petroleum	0.836	1.28
Bone	1.90	0.56	Alcohol	0.793	1.22
Magnesium	1.74	0.50	Amyl-alcohol		1.20
Coke		0.48	Olive Oil	0.915	1.12
Glue		0.48	Benzol	0.868	1.00
Sulphur	1.98	0.47	Water	1.00	1.00
Lead Ointment		0.40	Hydrochloric acid	1.26	0.86
Aluminum	2.67	0.38	Glycerin	1.24	0.76
Talcum	2.60	0.35	Bisulphide Carbon	1.293	0.74
Glass	2.60	0.34	Nitric acid	1.42	0.70
Chalk	2.70	0.34	Chloroform	1.525	0.60
Antimony	6.70	0.126	Sulphuric acid	1.841	0.50

[74] Sweet. Third Series of Cases of Injuries from Foreign Bodies Examined by the Roentgen Rays, with Results of Operation. *Trans. Am. Ophth. Soc.*, Vol. 12, p. 128, 1909.

[75] Weeks. On the Various Methods Employed for Localizing Foreign Bodies in the Eye by Means of the Roentgen Ray. *Tr. Am. Ophth. Soc.*, Vol. 10, p. 478, 1905.

Historical.

The use of the X-rays for localization purposes was for a time discouraged by several writers who considered that the media of the eye were impermeable to the rays. Dariex and Rochas[76] presented the results of their experiments before the *Académie des Sciences,* March 3, 1896, and concluded that the rays could not penetrate the transparent media of the eye.[77]

Van Duyse[78] did some experimental work with rabbits, and succeeded in demonstrating the fact that a foreign body in the eye would cast a shadow. He, however, believed that the bones of the skull would interfere greatly with the rays and suggested that salt injections in Tenon's capsule be used so as to force the eye forward into a proper position. His skiagraphs were taken obliquely, so as to include the anterior part of the globe and avoid the bones.

Lewkowitch[79] made experiments by placing the plate alongside of the nose and the Crooke's tube at the temple. He introduced a gilt spangle into the conjunctival cul-de-sac, and took two negatives—one of the eye adducted, the other with the eye abducted. With the aid of a bent wire as indicator, he then worked out the situation of the spangle by proportionate triangles. Both Van Duyse and Lewkowitch believed that it would be impossible to make a radiograph of the eye through the cranial bones.

Finally, the attempt was made by F. H. Williams, of Boston. He succeeded in obtaining a skiagram after a ten-minute exposure, which showed a foreign body one-fourth of an inch long by one-eighth wide, a fragment from a copper cartridge. It was removed by Dr. Charles H. Williams, by scleral incision, but the eye was afterwards lost.[80] This was the first attempt to show a foreign body in the globe, and was entirely successful, although exact localization was not attempted. The rays were passed across the nose through the thin tissue. A little later than this, Clark[81] made a skiagram of a piece of steel in the anterior chamber, and then went in at the corneal margin where, after some

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[76]Dariex and Rochas. Sur le cause de l'invisibilité des rayons de Röntgen. *Comptes rendus. Acad. des Sciences*, 1896, Vol. 122, p. 458; also *Encyclopédie Francaise d'Ophtalmologie*, Vol. 4, p. 708.

[77]Dariex Sur la perméabilité de l'oeil aux rayons de Roentgen. *Ann. d'ocul.*, 1896, Vol. 115, p. 218.

[78]Van Duyse. Les rayons Röntgen en chirurgie oculaire. *Arch. d'Ophtal.*, 1896, Vol. 16, p. 101.

[79]Lewkowitch. Röntgen-strahlen in der Augenheilkunde. *Centralbl. f. prakt. Augenheilk.*, 1897, Vol. 21, p. 21; also Röntgen Rays in Ophthalmic Surgery, *Lancet*, 1896, Vol. 2, p. 452.

[80]Williams. A case of Extraction of a Bit of Copper from the Vitreous, Where X-rays Helped to Locate the Metal. *Trans. Am. Ophth. Soc.*, 1896, Vol. 7, p. 708.

[81]Clark. A Question as to the Presence and Location of a Minute Fragment of Steel in the Eye Determined by the Röntgen Rays; Successful Removal by the Electro-Magnet. *Trans. Am. Ophth. Soc.*, 1896, Vol. 5, p. 711.

efforts, he succeeded in removing with a magnet a foreign body 1 mm. square. Exner[82] attempted to devise a scheme of localization by employing two leaden discs perpendicular to each other as fixed points, so as to have known measurements for triangulation. Ring[83] demonstrated a foreign body but did not localize it. Dahlfeld and Pohrt[84] experimented with shot and pieces of wire introduced into the orbits of cases of phthisis bulbi, and from these located a piece of steel 3 x 1 mm. in the globe. They advised several exposures at different angles, so as to clear the orbital margin. De Schweinitz[85] obtained an approximate localization by reference to the bony landmarks, and removed a foreign body measuring 4 x 2 mm. and weighing 7-16 grains. Fridenberg[86] took two negatives at right angles to each other and made the exposure through the entire thickness of the skull. The plates were bandaged—one to the front of the orbit, in the first exposure, the other to the temple, in the second exposure. The exposure lasted for 35 minutes. At the meeting of the American Ophthalmological Society in May, 1897, several papers on the subject were presented. William Thomson[87] reported a case in which the localization had been done by Sweet; Oliver[88] reported three cases in which the localization had been done by a method devised by Leonard after Exner's method of triangulation; and Sweet[89] gave his method with two metal indicators, which was the first accurate method of localization. After this Kibbe[90] attempted to localize the foreign body through its relations to bony points, and also used a shot bandaged to the eye as an indicator. Hansel[91] reported cases where localization by Sweet's method was successful.

The practicability of accurate localization of foreign bodies in the

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[82]Exner. Eine Vorrichtung zur Bestimmung von Lage und Grösse eines Fremdkörpers mittelst der Röntgen-Strahlen. *Wiener Klin. Woch.*, 1897, Vol. 10, p. 1.

[83]Ring. The Application of the Röentgen Rays in the Diagnosis of Foreign Bodies in the Vitreous. *Codex Medicus*, 1897, Vol. 3, p. 91.

[84]Dahlfeld and Pohrt. Der Nachweiss von Fremdkörpern im Auge, mit Hülfe der X-Strahlen. *Deutsch med. woch.*, 1897, Vol. 23, p. 282.

[85]De Schweinitz. A Piece of Steel in the Ciliary Body Located by Means of Roentgen's X-rays. *Am. Jour. of Med. Sciences*, 1897, Vol. 113, p. 566.

[86]Fridenberg. The Localization of Foreign Bodies in the Eye by Means of the X-ray. *Med. Record*, 1897, Vol. 51, p. 694.

[87]Thomson. Removal of a Piece of Steel Located by X-rays, from the Interior of the Eyeball. *Trans. Am. Ophth. Soc.*, 1897, Vol. 8, p. 88.

[88]Oliver. The Value of Repeated and Differently Placed Exposures to the Roentgen Ray in Determining the Location of Foreign Bodies in and about the Eyeball. *Trans. Am. Ophth. Soc.*, 1897, Vol. 8, p. 86.

[89]Sweet. (Method employed by him in locating foreign bodies in the eye by means of the Roentgen rays) being latter part of Thomson's (above) report. *Trans. Am. Ophth. Soc.*, 1897, Vol. 8, p. 91.

[90]Kibbe. The Utility of the X-rays in Detecting and Locating Metallic Particles in the Eye. *Archiv. of Ophth.*, 1897, Vol. 26, p. 517.

[91]Hansel. The Roentgen Rays in Ophthalmic Surgery. *Am. Jour. of Med. Sciences*, 1897, Vol. 114, p. 549.

eye being now established, the various methods followed rapidly, and have continued almost to the present time. They are very numerous and are of all grades of accuracy. The best ones are based on geometric calculations and give remarkably accurate results. These will be described later. Fluoroscopy also has been attempted in this connection, but in a situation like the orbit, where there is so much confusion from bony shadows and, as a rule, such small shadows to be viewed, it is worthless and cannot be depended upon.

Methods of Localization by Means of the X-Ray.

In general the methods which have been followed aim at geometric calculations from fixed points of measurement, calculations from bony landmarks—or from some indicator placed on the lid, in the cul-de-sac, or even sutured to the ocular conjunctiva—or from stereoscopic skiagrams. Pouzol[92] classifies them as follows:

1. Geometric.
   (a) Rectangular radiography (Radiguet and Guichard, Fouveau de Courmelles, Friedenberg, Friedmann, Galtier, Gorsch, Valencon, and Blondeau).
   (b) Double projections (Remy and Contremoulins, Sweet, Guilloz and Kibbe).
   (c) Mobility of the Eye (Grossman).
2. Anatomic Relations (Kibbe).
3. Stereoscopic (Ribaut and Marie).

Before describing in detail the most important methods, it will perhaps be as well to dispose of some of the less important ones. It need not be said that localization, to be of any proper value, in the succeeding operation, should be accurate, and only the methods which are accurate are worthy of serious consideration from a practical standpoint.

Use of the Stereoscope. The effort has been made to adapt the principle of the stereoscope to this use. Two radiographs are taken, at the proper angles, and are mounted in a single frame for insertion in the stereoscope, either as prints or as transparencies. This gives a very attractive and useful effect in connection with other uses of the X-ray, but it is obvious to depend on one's own judgment of distances for an estimation of the situation of the foreign body—even if it is shown with sufficient clearness—is a very inaccurate procedure in eye work and is of little more value than a single plate would be.

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[92]Pouzol. Contribution à l'étude du diagnostic des corps étrangers de l'oeil et de l'orbite; emploie des rayons X et du sidéroscope. Thése de Bordeaux, 1903; also quoted by Béal in *Corps étrangers magnetiques.*

Anatomic Relations. Here the main difficulty is that the bony points or landmarks do not show as clearly in the negative as a metal indicator, and the opportunity for error in measuring the distance from the bony point to the cornea is at least as great as in measuring from an indicator.

Geometric Methods of Localization.

Rectangular or Graphic Methods. The foundation of all that has been done here is the effort to dispense with the localizing apparatus and the succeeding calculations. Spectacles with cross-line centering opposite the corneal center have been used for this purpose[93]. Two negatives are made, one from behind the head with the cross lines opposite the corneal center; the other, a lateral view, with the cross lines of a single eye-glass, which is fastened to the temple, centering on the external canthus opposite the corneal center or at an arbitrary point on the temple. The resulting negatives give an approximate localization by showing the relation of the foreign body to the cross lines on the spectacle lens and to the frame. A similar method of localization is used by Fox[94]. He employs an oval form with cross wires, which is made of gold or some non-irritating metal, so shaped that it can be inserted into the conjunctival cul-de-sac after the eye has been cocainized. He takes two negatives—one from behind forward, the other laterally. These methods give only approximate results, and the opportunity for error in questions as to whether the particle lies at the posterior pole or in the orbit, in the lens or in the vitreous, on the ciliary body or below it, and other questions of like importance in the operation for removal of the foreign body, is very great. Their only advantage lies in the simplicity of the means employed. The advantage claimed that they save time, has been rather overdrawn. The part of the process that takes the most time is the exposing and the developing of the plates. When this is done, the method of triangulation by Hulen's method, or measurement by Sweet's, is a matter of a very few minutes. For those who cannot command the Sweet or Dixon apparatus, these methods are better than nothing, but they do not seriously compete with the more accurate methods.

Mobility of the Eye. Grossman[95] devised an ingenious plan before the general introduction of the more accurate methods. An exposure was made while the eye was looking up, then one while the eye was looking down. In the same way, exposures were made with the

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[93]G. G. Hall and E. T. Bruce, Louisville, Ky. Personal communication to the editor.

[94]Fox. *Practical Treatise on Ophthalmology.* New York, 1910, p. 508.

[95]Grossman. Localization of Foreign Bodies in the Eye by X-rays. *Liverpool Med. Chir. Jour.*, 1899, Vol. 19, p. 359.

eye in the position of extreme abduction and extreme adduction. The situation of the foreign body was inferred from the amount of displacement of its shadow with reference to the center of rotation of the eye.

Holth[96] of Christiania publishes a method, really a "Rectangular" method, which attempts greater accuracy by the method of attaching the indicators. Two indicators are used—small buttons of lead—and are sutured to the bulbar conjunctiva—one just above the cornea, the other just below. Bi-temporal and occipito-frontal negatives are made and the situation of the foreign body is measured by its relations to the indicators. While there is no question but that it is highly desirable to secure an exact point from which to measure, this method involves a surgical procedure, which is certainly objectionable.

Double Projections. The methods yielding the most accurate results are all based on geometric calculation, and have as their basis the comparison of the images of two exposures, or what may be roughly designated as "triangulation."

The first of these, and one of the best, was devised by Sweet[97]. He used two metal indicators which were connected, one pointing at the corneal center, the other at the temporal side at a known distance from the first. Two exposures were made, one with the tube horizontal to the plane of the indicators, but at a slight angle, so as to throw the shadow of one indicator farther forward than the other,—in this way leading to the identification of the indicators on the negative,—the other at any distance below this plane. The figure shows very well the principle of the method. Fig. 99 C represents the negative of the first exposure, while D represents the second exposure. The apparatus is extremely simple, in fact nothing is required but a properly made indicator with its attachment to the plate holder, which is bound to the head, as shown in the cut, Fig. 100. The important point is to have the indicators and the axis of the eyeball both parallel to the plane of the plate. The central indicator is placed exactly opposite to the center of the cornea, and the distance between the indicator and the cornea is measured by a rule. It is, of course, necessary to identify the indicators, and this is done easily, because the tube being anterior to the head of the patient, the shadow of the indicator opposite the center of the cornea will be the farthest back. In making the measurements on the negatives, it is necessary to continue the line of the indicator back until it is directly over the shadow of the foreign body, then letting fall a perpendicular to the foreign body. In this way the distance of the foreign body below the indicator is accurately determined.

In determining the situation of the foreign body, the position of the indicators is first entered on the chart, as shown in Fig. 101, A. and B, that is, in both the horizontal and the vertical section of the globe. On the diagram marked "Front view" is entered the measurements of the distance of the shadow of the foreign body below each indicator taken from the first negative, the one near the plane of the indicators, in this case represented by the letters C and D. A line drawn through these points represents the direction of the rays when the first negative was taken. In like manner, the

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[96]Holth. Bidrag til Röntgenlokalisation af Okulaere Fremmedlegemer, *Norsk. Mag. f. laegev.*, No. 8, 1905; see, also, translation, Zur Röntgenlokalisation okularer Fremdkörper, *Forts. auf den Gebiete der Röntgenstrahlen*, Vol. 8; also, translation, Procédé de localisation radiographique des corps étrangers de l'oeil et de l'orbite. *Ann. d'ocul.*, 1905, Vol. 134, p. 401.

[97]Sweet. Method employed by him. (as above). *Trans. Am. Ophth. Soc.*, 1897, Vol. 8, p. 91; see, also, Hansell and Sweet, *Diseases of the Eye.*

measurements are taken from the second negative and entered on the chart, represented by the points F and E. A line drawn through E and F represents the direction of the rays when the second exposure was made. The situation of the foreign body is at the intersection of these two lines. To determine the distance of the foreign body back of the corneal center, the negative with the tube horizontal is taken. The distance between the two ball-shaped ends of the indicators is measured, and this is transferred to the chart in the figure marked "Horizontal section." It is entered on the line above the marker and is represented by the distance BK. A line drawn through K and the in-

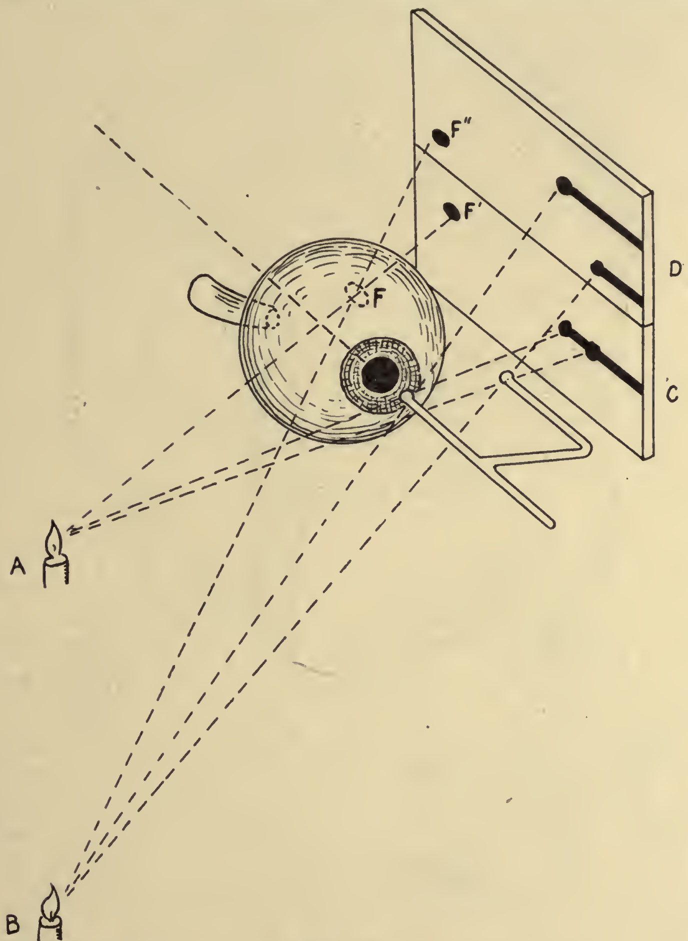


Fig. 99.
The Principle of Sweet's Method of Location.

dicator A, represents the direction of the rays, since in the negative the shadow of A is cast farther back than B, equal to the distance BK. On the same negative the distance of the foreign body back of each of the indicators is measured, and these measurements are transferred to the chart, in this case represented by the distances BJ and AH. A line drawn through J and H represents the plane of the shadow cast by the foreign body, and so it follows that a perpendicular drawn from the position of the foreign body in tho diagram marked "Front view" will represent the position of the

body at the point where it intersects the line JH. If the body is far back in the orbit or far away from the indicators, a source of error arises in the divergence of the rays, and it is better in this case to measure the distance of the tube from the cornea (this is indicated by the line KM). Now a line drawn from J to the tube will represent the divergence of the rays and the plotting will be more accurate. If the foreign body is in the orbit, a slight error arises in causing the patient to look at a fixed object so as to make the optic axis parallel to the plane of the plate on account of the rotation of the globe from the primary position. The plate-holder and the indicators are

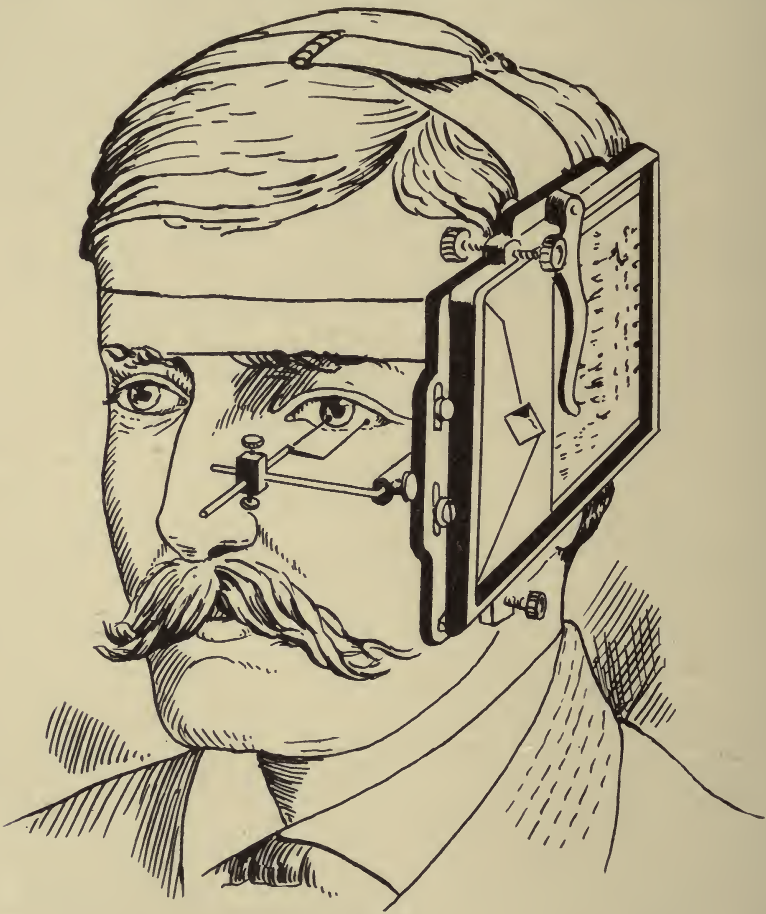


Fig. 100.
The Indicating Apparatus in Position. Sweet.

attached to the head on the side of the injured eye, as shown in the cut, and the tube is placed 12 inches to the opposite side and slightly forward. The patient is usually recumbent, to insure steadiness of the head.

The foregoing method has been used by its inventor in more than 700 cases, with accurate results, and there is no doubt that it is one of

the best. The measurements must be carefully laid out with mathematical accuracy, and it is best to have a chart similar to the figure, so as to maintain a certain uniformity. The size of the globe is made 24 mm., which is an average length.

Sweet's New Method.

At the meeting of the American Ophthalmological Society in 1909, Sweet presented a new method based upon the old, but in which the apparatus is such that the measurements do not have to be taken; the negative is simply placed upon a plate of "Focal Cöordinates" and the

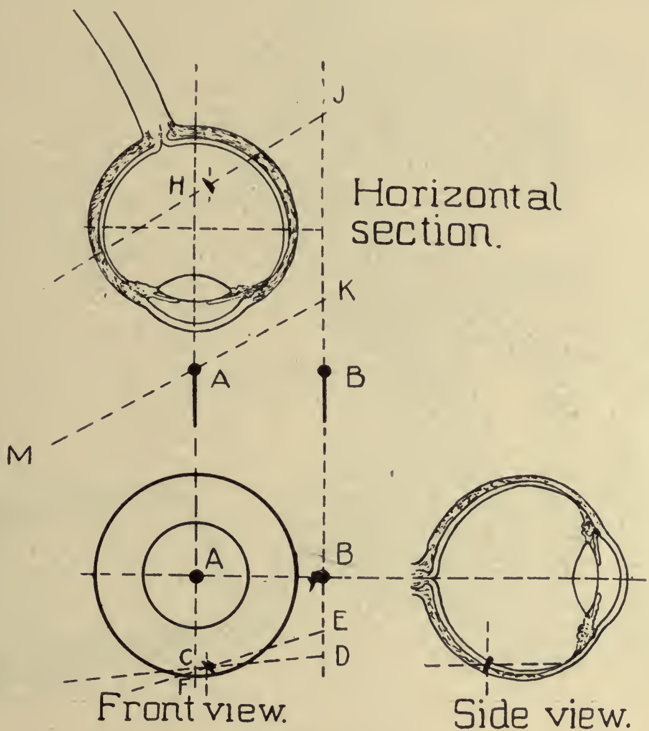


Fig. 101.
Diagram of Position of Foreign Body in Eyeball (Sweet).

readings taken directly. This method is best described in the author's own words.[98]

"In the new apparatus the planes of shadow of the foreign body are accurately determined by the instrument without the necessity on the part of the operator of taking measurements from the plates or drawing lines upon the chart. The tube-holder, indicating ball, and plate-holder are upon

[98]Sweet. Improved Apparatus for Localizing Foreign Bodies in the Eyeball by the Roentgen Rays. *Trans. Am. Ophth. Soc.*, 1909, Vol. 12, p. 322.

a movable stage and therefore preserve a known relation to each other which does not vary. The angle of the rays with the eyeball and the distance of the tube from the plate are always the same, so that one indicator is sufficient, and this consists of a small steel ball supported in a ring of translucent celluloid. The setting of this ball opposite the cornea is made by means of adjusting screws conveniently placed on the frame of the instrument. Accuracy in the measurement of the distance of the indicating ball from the center of the cornea is secured by means of a telescope and reflecting mirror. The mirror gives an image of a cross-wire and a lateral image of the cornea. Through the telescope the observer adjusts the instrument until the image of the cross-wire is in direct contact with the image of the summit of the cornea. When the adjustment is made, the indicating ball is

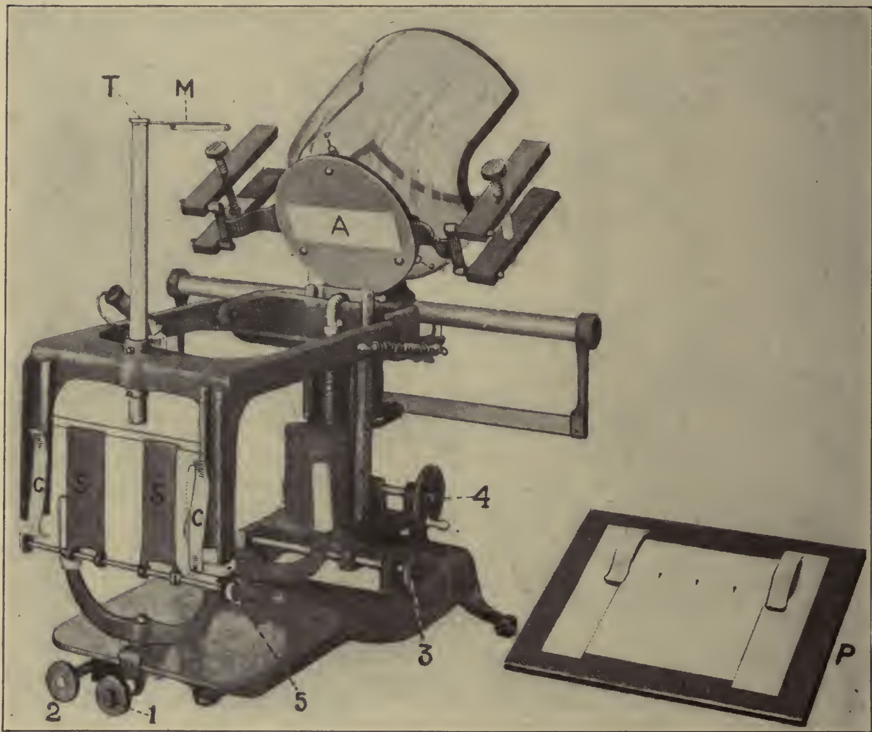


Fig. 102.
Sweet's New Localizer.

exactly 10 mm. from the center of the cornea. A miniature incandescent lamp, mounted in an adjustable shade, illuminates the side of the nose of the patient, insuring a well-lighted image of the cornea and cross-wire.

"Instead of a ball of cotton or other object for fixation, as in the older method, a circular mirror is placed at a distance of 12 inches above the injured eye. The patient gazes in the mirror and sees a reflected image of the injured eye and the circular celluloid disc with the steel indicating ball in its center. After the ball has been adjusted to a point opposite the center of the cornea of the injured eye, the patient, by fixing the ball with the seeing eye, prevents any movement of the eye during the exposure and holds the visual line of the injured eye parallel with the plate.

"In order to shorten the time of making the radiographs and lessen the

possibility of any movement of the patient or apparatus in changing plates, the two exposures in the new apparatus are made upon one plate, metallic shutters protecting those portions of the plate which are not to be exposed to the X-rays.

"The tube-holder contains the usual cylindrical lead-glass shield for protecting the operator from the action of the rays, with the customary lead diaphragm. The central orifice of the diaphragm is covered with aluminum, which offers little obstruction to the rays but lessens the risk of any unfavorable action of the rays upon the patient and guards against possible damage to the eyes in the event of breakage of the tube. The tube-holder slides upon a graduated rod, and the first exposure is made with the indicator at zero, in which position the rays pass in a direction corresponding with the horizontal plane of the eyeball. The second exposure is made with the tube at its farthest point to the right or left of the first position, de-

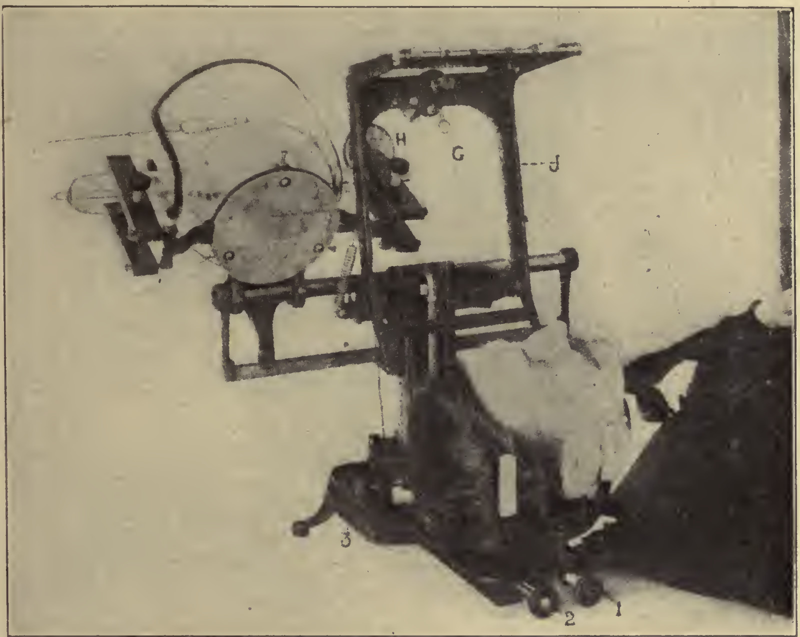


Fig. 103.
The Patient in Position (Sweet).

pending upon which eye is to be examined. The illustration (Fig. 102) gives a view of the complete apparatus.

"Since the relative position of the tube in reference to the indicating ball and the photographic plate remains to be fixed and known, it is readily seen that the direction of the X-rays in passing through the eyeball must follow a definite course, which is always the same for the two separate exposures. It is, therefore, possible to indicate on the localization chart the direction of the rays at the two exposures, and this has been done in the chart, a copy of which is reproduced in Fig. 104, reduced in size one-half. Only those lines representing rays 2 mm. apart are reproduced, but each line is drawn with the required amount of divergence to indicate the rays as coming from a point the distance of the tube from the photographic plate.

"*Method of Employing the New Localizer.*—The apparatus is arranged

as shown in Fig. 103. The patient lies with the head on a platform of hard fiber, with a pillow beneath the shoulders and a small sand-bag under the head and neck. The upright supports for holding the head are now adjusted by means of the wheel, 1, and the jointed part of the apparatus, J, containing the indicator is brought down in position. The indicating ball, G, is now roughly adjusted until it is opposite the center of the cornea and about 12 or 15 mm. distant. The patient looks with the uninjured eye into the mirror, M, and fixes upon the iris or cornea of the injured eye, or, better, upon the indicating ball in the center of the celluloid disc. The indicating ball is now carefully adjusted directly over the corneal center by means of the wheels 2 and 3, and the correctness of the position verified by observation through an opening in the mirror, M. The operator then adjusts the light of the small electric lamp so that the side of the nose next the injured eye is illuminated, but the light is not thrown into the eye. With this area

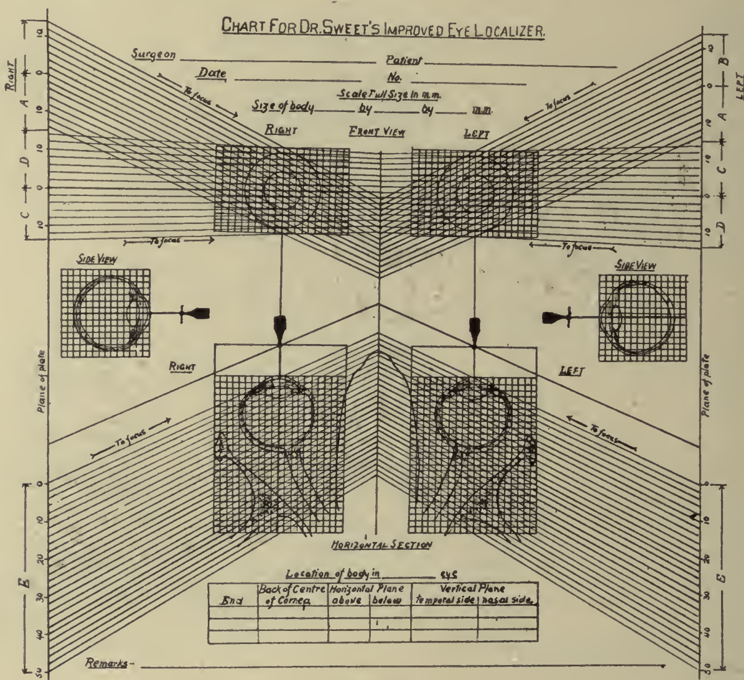


Fig. 104.

Localization Chart, with Lines Representing the Course of the X-rays, (one-half actual size). Sweet.

lighted, it is possible to see clearly through the telescope, T, when the cross-wire is exactly tangent with the summit of the cornea. The movement necessary to secure this position of the wire is made by means of the adjusting wheel, 4. When the image of the cross-wire touches the image of the corneal summit, the indicating ball is exactly 10 mm. from the eyeball.

"The photographic plate is inserted beneath the spring clips, C C, the shutters, S S, moved so that the center area is open (Fig. 102), and the tube-holder adjusted to the zero point on the sliding scale. The current is turned on, and one exposure made. The tube-carriage is then moved to the limit of the sliding rod, always in the direction of the chin of the recumbent patient (to the end marked R if the radiographs are made of the right eye, and to L if of the left eye). The upper shutter is moved to cover the ex-

posed central portion of the plate and uncover the unexposed portion. The current is again turned on and the second exposure made. The time of exposure for the second picture should be about one and a half times that of the first, to allow for the increased distance of the tube from the eye.

"After the plate is developed it is placed in the frame, P, (Fig 102) containing the key plate of focal coördinates (Fig. 105) with the film side

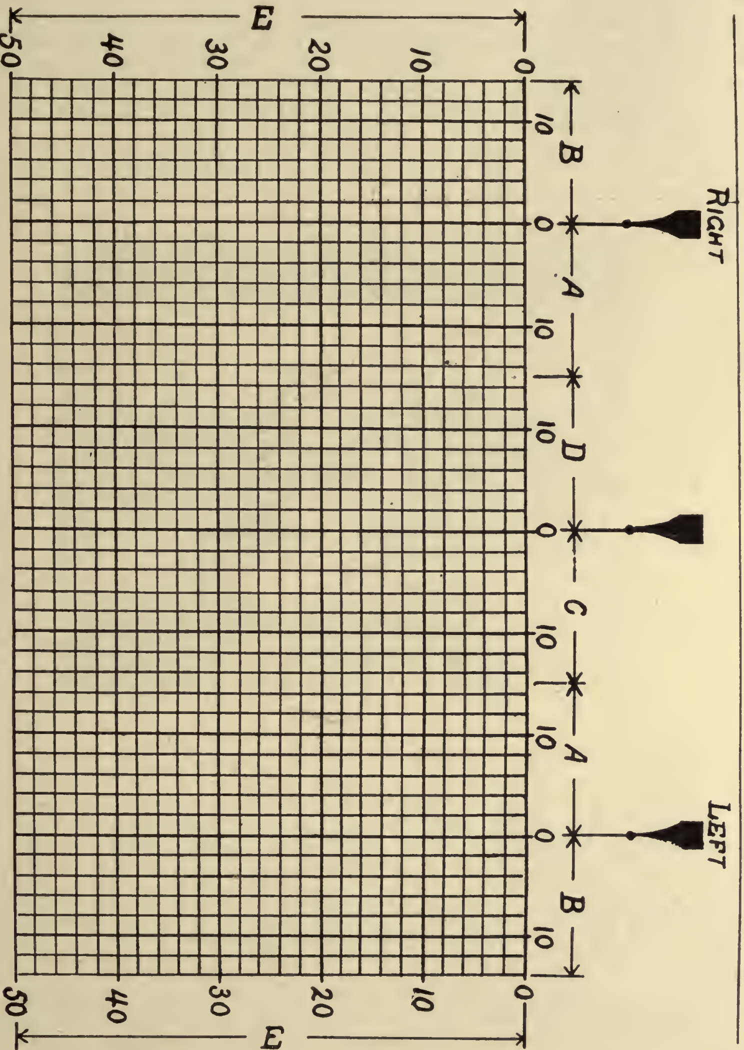


Fig. 105.
Plate Showing Focal Coördinates, (three-fourths actual size). Sweet.

of the radiograph next to the key plate. The radiograph is moved until the shadow of the indicating ball of the first exposure is in apposition with the middle ball on the key plate and the heavy horizontal line of the radiograph parallel with the horizontal line on the plate. Holding the frame body with respect to the vertical lines of "C" and "D," a reading is made to the light, there is noted the position occupied by the shadow of the foreign

of the line or lines which pass through the body, and this is transferred to the corresponding lines of the "C" or "D" scale of the chart, to the right or left side, depending on which eye is under examination. Without moving the plate the "E" reading is similarly made and transferred to the chart. To take the "A" or "B" reading the plate is shifted slightly until the image of the indicating ball on the second exposure coincides with the "Right" or "Left" ball of the vertical coördinates "A" or "B." The line or lines of the "A" or "B" coördinates which cross the shadow of the body are noted and indicated on the "A" or "B" lines of the chart. The horizontal coördinate "E" should be the same in both readings. If the focus point on the anode of the tube was accurately set by the cross-lines on the lead-glass shield of the tube-holder, the images of the indicating ball on the plate will coincide simultaneously with those on the transparent key plate, and it will then not be necessary to reset the plate to read the position of the "A" and "B" coördinates.

"After the three readings have been transferred to the chart, the point of crossing of the "A" or "B" and the "C" or "D" lines is found, which gives the location of the foreign body in reference to the front view of the eye-

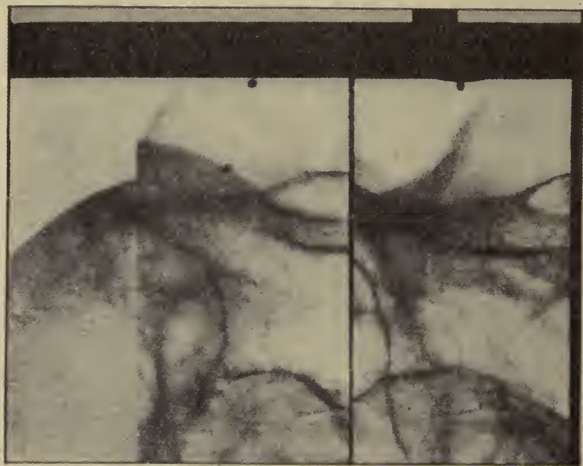
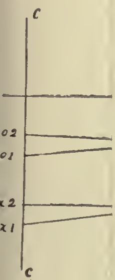


Fig. 106.
Radiograph of Foreign Body in the Eye, (three-fourths actual size). Sweet.

ball, indicating its situation above or below the center of the cornea, and to the nasal or temporal side of the vertical plane. Where a vertical line from this point crosses the "E" reading on the horizontal section of the globe, it gives the depth of the body in the eyeball or orbit. In bodies of large size both ends should be localized to give the position in which the body rests in the globe. The situation of the body on the side view is determined by transferring its measured depth from the horizontal section and its distance above or below the horizontal plane from the front view localization.

"The new apparatus is based on the same general principles as was the old, but its mechanical features eliminate some of the errors that may occur in the use of the present instrument through carelessness of the operator in making the measurements and transferring them to the chart. The inexperienced worker in eye localization is also relieved of the necessity of studying out the position of the tube and the direction of the lines of shadow at the two exposures. The construction of the new apparatus insures that these factors are positively determined and recorded. The accuracy of the localization depends only upon the care with which the operator adjusts the indicating ball opposite the center of the cornea and at the


c
o2
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definite and fixed distance from it. After the exposures are made and the plate developed, the determination of the situation of the foreign body is simply a question of reading from a keyplate and transcribing these readings to a chart."

This method has the advantage, in common with the old one, of taking the negative with the rays somewhat oblique so that no greater thickness of bone is penetrated than can be avoided. It necessitates the use of special apparatus and, while undoubtedly easier to work, is more difficult to understand than the old one. It furnishes accurate results.

Mackenzie-Davidson's Method.

This method which, in its modified form, seems to the writer the best, was first published by Mackenzie Davidson[99], January 1, 1898. It was devised, not especially for foreign bodies in the eye but for foreign bodies anywhere in the body, and was accurate from the beginning though somewhat cumbersome. The essential principle of the method was the diagramatic reproduction of the course of the rays in a duplicate of the apparatus used for the exposure, and which he called the "localizer."

His apparatus consisted of a table, to which was attached two upright bars connected by a cross-bar for the support of the Crookes' tube, and a plate of vulcanite with two cross-wires on it dividing the plate into four equal parts. The wires on the plate were brushed with India ink so that a mark would be left on the patient's skin. The plate was placed on the table and the vulcanite on top of the plate, the two being centered below the middle of the cross-bar by means of a plummet, in such a manner that the cross-bar was parallel with one cross line and at right angles to the other. The cross-bar being graduated, the center of the lines was placed exactly below the zero mark. A coin, or some opaque object, was placed on the corner of the photographic plate so that the plate after development could be properly placed. The affected part was then placed on the vulcanite plate and the exposure made. There were two exposures made with the tube a given number of centimetres on each side of the zero point. The resulting negative gave two images of the foreign body, and the marks left by the ink on the patient's skin gave the position from which to apply the measurements after these had been worked out. The localizer was an exact duplicate of the exposing apparatus, and consisted of two uprights and a graduated cross-bar, all of exactly the same measurements as the original. There was a mirror under the bar with cross lines scratched on it. The negative was centered under the zero mark of the cross-bar, so that the cross lines were in the same position as they had been when the exposure was made, and silk threads were used to represent the course of the rays. These threads were attached to the cross-bar at the positions of the exposures and held in place on the negative by weights connected with the threads, being run directly to the shadows of the foreign body, visible by means of the light reflected in the mirror. The point of intersection of the rays, as represented by the crossing of the threads, gave the position of the foreign body, and it was only necessary to measure the distance from this point to the cross lines, to have an absolute guide, based on the marks on the patient's skin.

This method was first adapted to the eye in a case of Treacher Collins[100].

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[99]Mackenzie-Davidson. An Apparatus for Exact Measurement and Localization by Means of Roentgen Rays. *Br. Med. Jour.*, Jan. 1, 1898.

[100]Mackenzie-Davidson and Treacher Collins. On the localization of Foreign Bodies in the Eye and Orbit by the Roentgen Rays. *Trans. Ophth. Soc. United Kingdom*, 1898, Vol. 18, p. 200.

Two exposures were made, as before, but a small piece of lead wire was attached to the lower lid at a point which bore some definite relation to some point of the eyeball, as a scar. When the negative was placed upon the localizer, the position of the wire indicator was first determined, and a needle was left to indicate this. Either one of two head rests was used, one with the patient lying down, the other with the patient sitting up. While this method gave accurate results, the use of the localizer was somewhat troublesome. It was very easy to disturb the positions of the threads and great delicacy was necessary in taking the measurements.

Hulen[101] modified the method by having the patient sit up and grasp a wooden rod in the teeth (Fig. 107). This rod was attached to a frame and was at right angles to the plate-holder, which had cross-wires on it as in the old apparatus. An upright holder was constructed for the Crookes' tube, which was measured so that the tube was at a known distance from the plate, and the anode was in the horizontal plane and opposite the intersection of the cross-wires. This holder allowed the tube to be raised or lowered.

Fig. 107.
Hulen's Method of Localization.

The marker of fuse wire was attached in the same manner as in the old method and the distance of the marker from the cornea, below and forward, was recorded. The first exposure was made with the tube in the horizontal plane, and then the tube was raised a definite distance, usually three inches, and a second exposure made on a second plate. The patient was instructed to look at some object straight ahead, so as to bring the eye in a correct position, and was kept as still as possible while the two exposures were made. The lines of direction of the rays were then represented by laying them out on a drawing board according to the known measurements, as will hereafter be described.

Dixon's Method.

A description of this method was first published in its entirety in

[101]Hulen. A Simple, Accurate, and Rapid Method of Localizing Foreign Bodies in the Eye. *Jour. Am. Med. Ass'n*, 1904. Vol. 42, p. 881.

1906.[102] He originally used Mackenzie-Davidson's method, but soon modified the procedure by using a single ball pointed indicator, after Sweet's model, which he placed opposite the center of the cornea. He placed the patient in the recumbent position and devised a head rest which, while simple, meets all the requirements. He used Hulen's method of plotting with T-square and rule. So that his method in its final form is based on Mackenzie-Davidson's principle, with Sweet's indicator and Hulen's method of plotting. It is in use at the New York Eye and Ear Infirmary and the Manhattan Eye, Ear, and Throat Hospital, and seems to the writer the most satisfactory of all.

The apparatus is mounted on a 22 inch table (Fig. 108), which is placed at the head of the bench upon which the patient lies, and can be reversed,—depending on which eye is affected. It has a vertical plate-holder, A,—large enough to hold a 4 x 5 plate in its envelope,—which is erected on a platform elevated by cleats to compensate for the shoulders of the ordinary sized patient. Small blocks of wood of different sizes can be used beneath the back of the neck to act as a pillow and to keep the proper elevation. The plate-holder is supplied with the usual cross-wires (3) and a spring (8) to retain the plate in position during the exposure. A mouth gag (7) of aluminum is attached to the face of the frame with a jamb-nut, to hold the patient's head steady. A clamp (19), with a rubber band which can be pressed tight to the side of the head and screwed fast, gives additional stability. A steel rod (5) is attached to the frame and extends well up over the patient's head. It has a sliding cross-piece of brass tubing at the top through which a thread is run to a little woolen ball (16), balanced by a piece of lead at the other end of the thread. The rod can be rotated and fixed by a screw (6) so that the ball can be adjusted in whatever position it is desired to have the patient look. An upright sight (4) is fastened to the other end of the platform for the purpose of adjusting the tube in the horizontal plane, the lower part of the notch of which is at the exact height of the cross-wire center. On the frame is placed the instrument for squaring the head (1), which consists of a sleeve with a wire with a ball at each end, so that it may be pointed down at the glabella and then rotated to the horizontal position. The tube-holder consists of (B), a box (18), 2 x3 inches inside, open at each end, within which moves a pillar (11) controlled by a worm gear operated by a crank (15) from the opposite side of the table. Attached to the upper end of the pillar is a diaphragm (9) adjustable for height. It is supplied with cross-threads for alignment with the cross-wires in the plate frame. A projecting arm (14), one end of which is morticed into the head of the pillar, carries a cross-piece (12) to which is attached the arrangement (13) for clamping the tube. Both the arm and the cross-pieces are slotted so that the parts supporting the tube can be moved in all necessary directions and clamped. The arm (14) is graduated so that it is possible to read the distance of the center of the target from the plate. The face of the upper end of the pillar (11) and the lower end of the diaphragm (10) are graduated in centimeters,—six above and six below the zero mark. Attached to the box (18) is an adjustable indicator (17) to measure the distance the tube has been moved.

The writer uses the wooden "pillow" without the mouth-gag, and prefers a Brickner stand, as shown in Fig. 109, which allows the tube to be raised and lowered at will and is attached to the side of the table at exactly 50 cm. from the plate holder, so that no measurement is necessary (Dixon's original plan). The indicator consists of a ball pointed

[102] Dixon. On the Localization of Foreign Bodies in the Eye and Orbit. *N. Y. Eye and Ear Infirmary Reports*, 1906, Vol. 12, p. 12.

rod attached to a head band, which is strapped to the patient's head, thus avoiding any danger of injury to the eye by a sudden move (see Fig. 110).

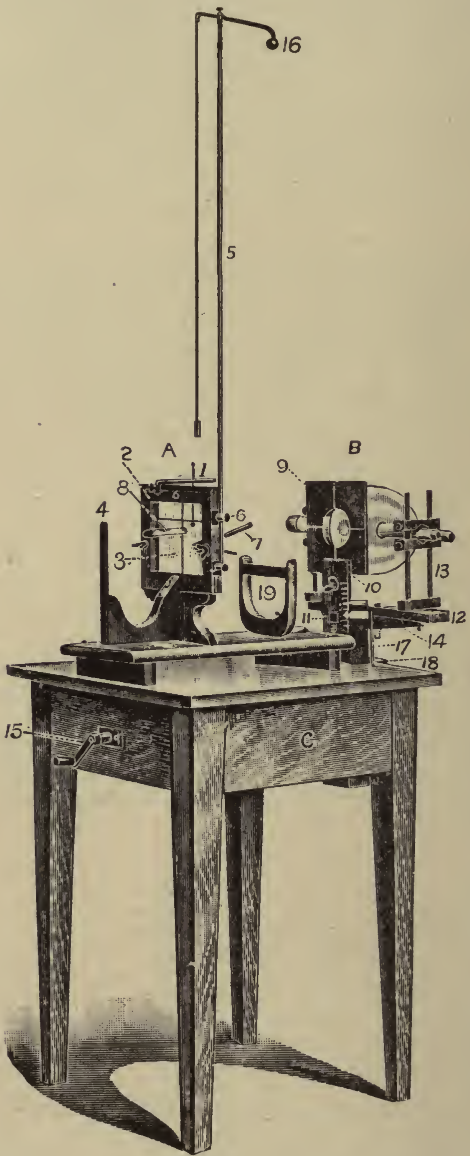

Fig. 108.
Dixon's Apparatus for Localization.

In using the method, the tube is first adjusted to the horizontal plane by sighting across the wires at the anode, the tube being exactly 50 cm. from

the intersection of the wires. The indicator is then strapped to the patient's head, he is placed on the table, on his back, with his head raised by a wooden pillow to the proper height, so that the affected eye, which is placed next the plate-holder, is in the part of the negative nearest the top

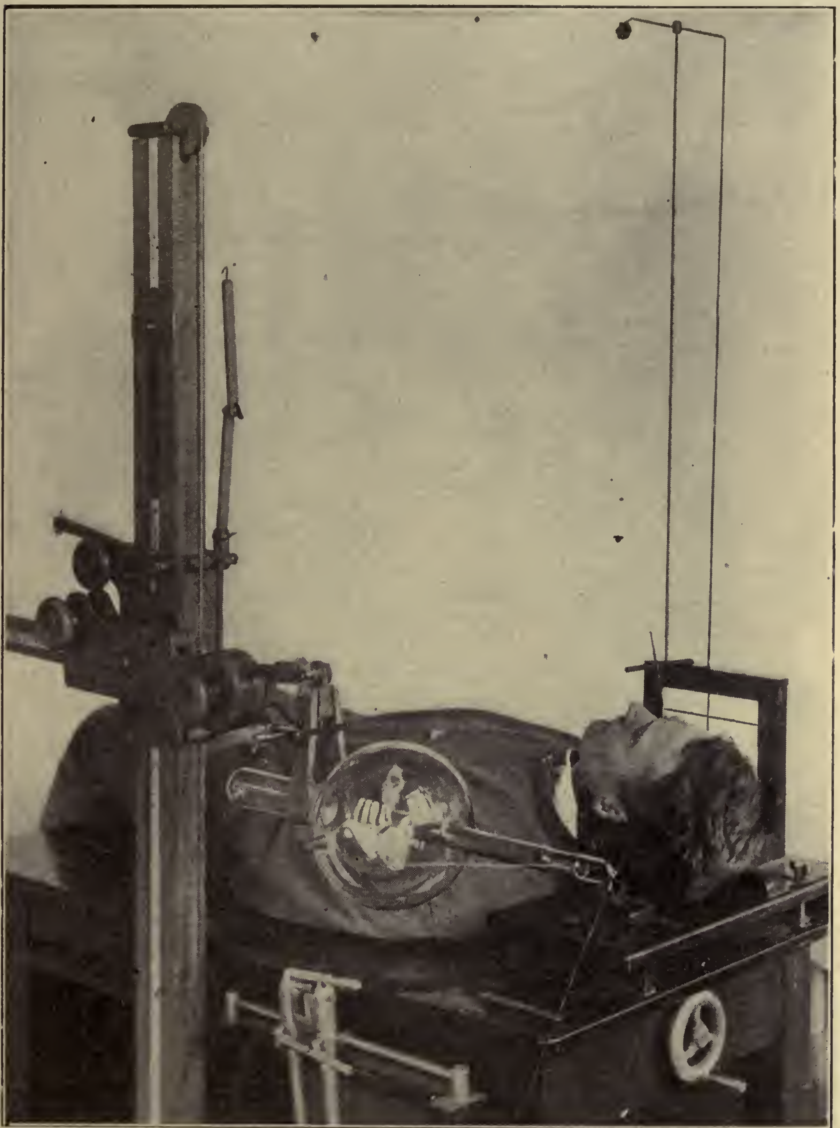

Fig. 109.
The Patient in Position. Dixon's Method. (The indicator is not shown).

of the head and below the horizontal wire. The vertical wire should run at the level of the floor of the orbit, so that there will be little chance of a very small body being concealed by the wire. The head is now squared by

means of the squaring instrument, which is then removed from the frame. The woolen ball is now lowered directly over the patient's eye, and when the proper direction has been secured it is drawn up as far as it will go and the patient is instructed to look steadily at the ball during the time of both exposures. In the case of squint, the direction must be modified until the affected eye takes the proper position. The indicator, (see figure), is then more accurately adjusted and placed exactly opposite to the corneal center and as close to the cornea as possible,—usually about 3 mm. The distance is then measured with a millimeter gauge, and recorded. The plate is then put in position, the tube raised 3 cm. above the horizontal plane, and the first exposure is made. The plate is changed, the tube lowered to 3 cm.

Fig. 110.
The Indicator in Position. Dixon's Method.

below the horizontal plane, and the second exposure is made. The time of exposure varies, but under fair conditions an exposure of more than 10 seconds is never necessary. The plates are developed, and the plotting can be done immediately, without waiting for the plates to dry.

Plotting.—The first step is the identification of the exposures, and if these have not been kept separate it is a simple matter to tell which is which by the relation of the indicator to the cross-wire which represents the horizontal plane (Plate IV). In the negative from the first exposure the indicator extends farther down, below the wire "a," where the tube was displaced upward, than in the second where the tube was displaced downward. A drawing board with T-square, triangle, and compass, with a scale rule

are necessary, with the special chart figured in the cut. This chart (Plate IV) represents three sections of the globe, right and left, of an average diameter of 24 mm. The chart was devised by Drs. Weeks and Dixon after Sweet's chart, and is graduated in millimeters. It is best in plotting to use the full scale, as it is really easier and there is less opportunity for inaccuracies. The measurements must be made with mathematical accuracy, and it is best to use a fine-pointed pair of compasses and a hard fine-pointed lead pencil. The horizontal plane (Plate IV) as is first drawn, and then a perpendicular at the right end, bb, which represents the plant of the displacement of the tube. At the left, exactly 50 cc. from bb, is drawn another perpendicular, which represents the position of the plates, cc. On the line bb is indicated the positions of the tube at the time of the exposures, the first 3 cm. above the line aa, (Ex. 1), the second 3 cm. below the line (Ex. 2). The distance of the ball end of the indicator below the horizontal plane, which is the same as the wire aa, is now measured in each negative and measured on the line cc at the points "o^1" and "o^2," and lines representing the course of the rays are drawn from these points to the positions of the tube during exposure, respectively. The point at which these lines intersect represents the position of the indicator, o. In the same way, the distances of the foreign body below the line aa are measured and transferred to the line cc at the points x^1 and x^2. Their intersection represents the situation of the body, x, in the case shown,—a piece of stone. A perpendicular is now let fall from "o" and a line is drawn, at right angles, to "x." These distances are measured, and we find that the foreign body is back of the indicator at 17 mm. As the indicator was three mm. from the cornea, it follows that the foreign body is 14 mm. back. As x is nearer the plate, it follows that the foreign body is so much to the temporal side of the indicator (corneal center),—in this case, 1½ mm. Now, taking either radiograph, we measure the distance of the indicator above the line bb, and the distance of the foreign body above the line bb, and the difference,—in this case, 3mm.,—represents the distance of the body from the corneal center in the vertical plane. Either negative may be used for this last measurement, since no displacement of the tube has taken place in this direction. The three measurements are then entered on the chart, as shown in the cut.

This is substantially the same as Hulen's plan for plotting, and gives remarkably accurate results. Besides the location of the foreign body, it gives two dimensions of the size. If the particle is long and thin, it may be necessary to make two sets of measurement—one from each end—but as a rule this is not necessary. It is enough, in the majority of cases, to make the measurements from the anterior end or center, and, the size being directly measured on the plate, the entire particle can be sketched in accurately.

Advantages of the Method. The most patent advantage of this method is its simplicity. It is readily understood and the *rationale* is readily followed. It is quickly done. If one is familiar with the procedure, and if everything is ready at hand, it is possible to complete the whole process in half an hour—exposures, developing, plotting, and all. The plotting takes but a few minutes—five or ten at the outside. The advocates of the so-called simpler methods have done nothing except dispense with the measuring and plotting. The adjustment of any sort of indicating apparatus takes as much time as the Dixon head rest, and the development is, of course, the same. It has been urged against X-ray localization, especially by the advocates of the sideroscope and the giant magnet, that these latter are much quicker. But it is a very

doubtful point whether the time consumed in the X-ray examination adds materially to the gravity of the prognosis, especially when the foreign body has been in the globe for a matter of hours, and the accurate information gained is surely worth the disadvantage.

The Indicator. It is undoubtedly of greater importance to be accurate in localization in the anterior part of the globe than in the posterior, so the most desirable position for the indicator is in the center of the cornea. In this position the liability of error, when the foreign body is situated in the lens or on the ciliary body, is very small, and the measurements should be within 1 mm. of the exact location. In the posterior segment of the globe, farther away from the indicator, a slight error in accurate plotting will give a wider error in the angle the farther the foreign body is from the indicator. The size of the globe being an unknown factor, which can only be inferred from the refraction of the fellow eye, it is not always possible to say with certainty that the foreign body is in the retina or in the orbit outside of the globe. However, this latter difficulty applies to all methods, and is rather due to our lack of knowledge of the anatomical measurements in the particular case than a defect in the method. Certainly, the methods which rely on an indicator placed on the lids, external canthus, etc., have a much larger element of uncertainty, as the distance must be measured to the corneal center, in any event—three measurements are often necessary—and it is difficult to be sure that the distance has not varied between the time of measurement and the time of exposure. Finally, the nearer the indicator is to the cornea, the less chance there will be for error in this measurement.

The author prefers the method of Dixon to that of Sweet in that it is more readily understood, the apparatus is fully as easily managed, and the results are as accurate.

Ramsay's Modification of Mackenzie-Davidson's Method.

Ramsay[103] uses a modification which is somewhat simpler as regards the apparatus used. He has the patient sitting in a chair with a plateholder and chin-rest attachment, so that the plate is closely applied to the side of the injured eye. A small wire cross is fixed to the external orbital margin on a level with the outer canthus, to act as an indicator. The Crookes tube is then placed on a level with the eye and 300 mm. from the center of the cornea, "the center of the anode being exactly opposite the center of the small wire cross." (This is evidently somewhat approximate). Two exposures are made, the one with the tube 40 mm. in front of the plane of the indicator, the other 40 mm. behind. On the developed plates the distance of the foreign body from

[103]Ramsay. *Eye Injuries and their Treatment.* Glasgow, 1907, p. 84.

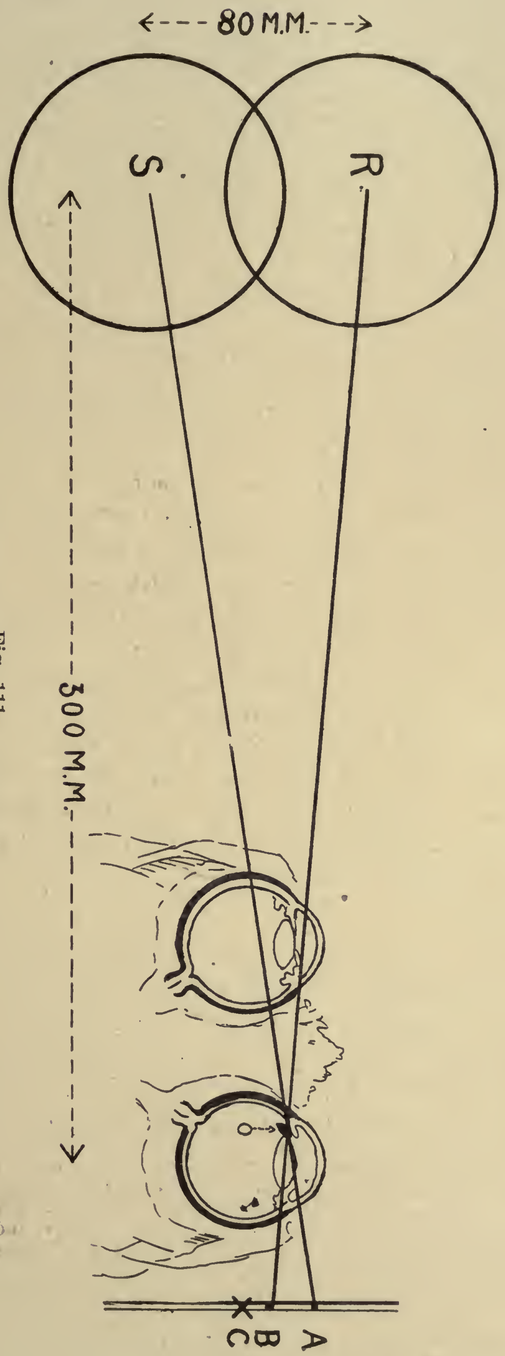

Fig. 111.
Ramsay's Method of localization.

the indicator is measured, as is shown by the positions A and B in the diagram (Fig. 111), C being the shadow of the indicator.

Assuming that AB=9 mm., then, according to the laws of similar triangles, we have:

RS : SO :: AB : BO, or 80 : 300 :: 9 : BO ∴ BO = 270/8 = 33.75 mm.; so that the foreign body is situated 33.75 mm. to the nasal side of the indicator, or the outer canthus. It will be noted, that the distance of the tube being measured from the corneal center, there is a slight error in the figure "300," which should represent the distance of the tube from the foreign body. However, this is small in proportion, and is disregarded in the method. The antero-posterior distance is computed by taking the middle point between A and B, or by the formula CA+CB÷2, which in the illustrative case equals 14+5÷2=9.5 mm. The vertical distance is measured directly from either negative, as both are on the same vertical plane.

While these measurements may be sufficiently accurate for all practical purpose, as is claimed by the author of the method, it is evident that the resultant figures give the distances from the indicator only, and are therefore open to a greater error than where the indicator points directly to the corneal center, as in the methods of Sweet and Dixon. In plotting the location of the foreign body with reference to the envelopes of the globe, a further measurement must be taken into account, i. c., the distance of the indicator from the corneal center; and while this may be estimated with a fair degree of accuracy, it must be done at the time of exposure, as any change in the axis of the globe would necessarily introduce an error into the calculation. The method, while simple and convenient, takes as much time as the more accurate methods, and cannot be reliable.

Method of Guilloz.

This method, which is mentioned as the best in the *Encyclopédie Française d'Ophtalmologie*[104] is also quoted by Beard.[105] Two tubes are used and exposed at the same time. They are aligned exactly 50 cm. above the plate, which has a wire wrapped around it and placed so that the wire is exactly parallel to the line joining the anticathodes.

The patient has three indicators attached to a point just external to the supra-orbital notch, to the margin immediately below the first, and to the external orbital rim, respectively. The patient lies with the affected eye next the plate, and fixes so that the orbital axis is parallel to the plane of the plate. The resulting negative gives double images, or "biconic projections" of the indicators and the foreign body. The indicators are easily identified by their positions and lines connecting the shadows of the same indicator should be parallel to the shadow of the guide-wire. The distances between the indicators are measured on the patient, and the distance of the

[104] *Encyclopédie Française d'Ophtalmologie*, Paris, 1905, Vol. 4, p. 773.
[105] Beard. *Ophthalmic Surgery*, 1910, p. 643.

tubes from each other and the distance from the plate (50 cm.) being known, it is easy to work out the distance of the foreign body from the indicators by triangulation (as in Mackenzie-Davidson's method), which is done by a special instrument. The distances are measured on bits of wire, which are then attached to small pieces of lead, one for the foreign body, to which the three wires are attached, and the other end of each wire to a piece of lead which represents the position of each indicator. A special form of compass is now used, with three adjustable outer points, which are adjusted to the indicators on the patient's orbit, as a matter of verification, and one central point to represent the position of the foreign body. The points are first fixed in position, and then stuck into the three lead pieces representing the indicators, and the external one is stuck into the lead representing the foreign body. It will be remembered that these three outer leads are connected to the central one by wires which have been measured, and it follows that if the central point is pressed down until the wires are taut its point will represent the position of the foreign body. This central point can be slid up and down without altering its direction, and is graduated. The distance back of the plane of the three indicators is read on the scale and then the central point is withdrawn to a sufficient distance so that it will not touch the cornea, the leads are removed, and the compass is placed on the indicators on the patient's orbit, when the central point will show by its direction where the foreign body lies,—always providing that the patient's eye is in the same position as it was during the exposure.

To the writer, this procedure seems unnecessarily complicated. The three indicators make the proceeding cumbersome and offer no advantages over *one* indicator placed over the corneal center. The calculation is as easy with one indicator as with three, and the method of anatomical localization is troublesome and gives only a more or less *graphic* representation of the location of the foreign body when it is done. To be sure, in the Sweet and Dixon method the surgeon about to operate must judge—when he is shown that the foreign body is 10 mm. back of the corneal center—just how far that is, but this is not more exact in the method of Guilloz, while the chart which is dispensed with by Guilloz is often of the greatest value, particularly when the foreign body is in the anterior segment and the surgeon wishes to know whether the particle is in the lens, on the ciliary body, or in the vitreous.

ELECTRO-MAGNETS.

Historical.

The magnet was primarily employed in ophthalmic surgery by Dixon[106] of London, in 1859, although an ineffectual attempt had been made by Meyer[107] of Minden as early as 1842. Dixon's case had part of the blade of a pair of scissors in the vitreous, where it had been for four weeks. He used a large permanent magnet, and drew the steel close to the wall of the globe, from which point it was removed by forceps

[106]Dixon. Foreign Body in the Centre of the Eye; Extraction and Recovery of the Eye. *Medical Circular*, 1859, Vol. 14, p. 188.

[107]Meyer. Extraction eines Stahlsplitters aus dem Auge mittelst des Magneten. *Med. Zeitung. hrsg. v. d. Ver. f. Heilk. in Preussen*, 1832, Vol. 11. p. 50.

through a scleral incision. In 1874 McKeown[108] of Belfast succeeded in removing a piece of steel from the vitreous and saving the eye. He used a permanent magnet eight inches long, one inch broad, and one line thick, tapering to a point at each end. He inserted the tip of the magnet into the vitreous through the scleral wound and withdrew the foreign body. The method was commended by Snell[109] and the idea was soon taken up by many other ophthalmologists.

Hirschberg[110] in 1877, after some preliminary experimentation constructed an electro-magnet consisting of a closely wrapped coil of fine copper wire surrounding a soft iron bar, one end of which was drawn out at the point. The ends of the wire were connected with a powerful galvanic current. This magnet, somewhat modified, has held its own and is still extensively used. It can be operated by a storage battery or in connection with the street lighting current. In connection with one zinc carbon element it will lift at its point a weight of iron of from 100

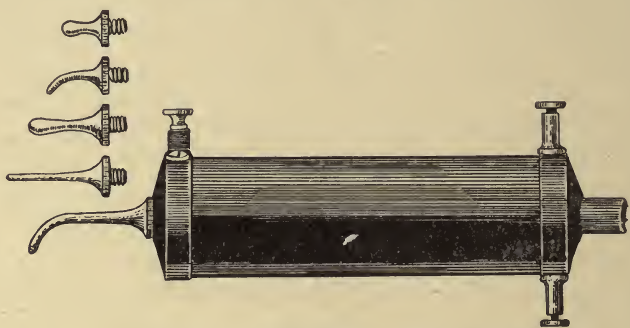

Fig. 112.
Hirschberg's Magnet.

to 120 g., while with five cells as much as 575 g. can be lifted (Gruening[111]). Several different forms of point are now constructed which are detachable and can be sterilized. This magnet has not, however, attractive force enough to influence a small foreign body unless the point is brought into direct contact with the particle, and indeed Hirschberg's original plan was to insert the tip into the interior of the globe and withdraw the foreign body on the magnet's tip.

[108]McKeown. Extraction of a Piece of Steel from the Vitreous Humour by the Magnet; Recovery of almost perfect vision. *British Med. Jour.*, 1874, Vol. 1, p. 800.

[109]Snell. On the Employment of the Magnet and Electro-magnet in the Removal of Iron and Steel Fragments from the Interior of the Eye. *Brit. Med. Jour.*, 1881, Vol. 1, p. 843.

[110]Hirschberg. On the Extraction of Chips of Iron or Steel from the Interior of the Eye. *Arch. of Ophth.*, 1881, Vol. 10, p. 369; also, Ueber die Magnet-Extraction von Eisen-splittern aus dem Augeninnern. *Berl. klin. Woch.*, 1883, Vol. 20, p. 61.

[111]Gruening. Norris & Oliver. *System of Diseases of the Eye*, Vol. 3, p. 710, 1898.

Sulzer[112] modified Hirschberg's magnet by shaping it like a horseshoe, basing his idea upon the fact that this shape gives the greatest attractive force in a permanent magnet. However, his idea has not been generally adopted.

Snell[113], in 1881, first published a description of his magnet, which consisted of a core of soft iron wound with copper wire, with detachable points of various shapes. It was somewhat similar to Hirschberg's.

Gruening[114] in 1880, described a small permanent magnet which is at times very useful for extracting foreign bodies from the anterior chamber, or wherever they may be brought plainly into view. It consists of a number of steel rods fitted into an iron cap at each end, one of which is provided with a conical point of malleable iron. By contact with the dynamo, the apparatus is made magnetic, and remains charged for about one year. The point must be brought into direct contact with the foreign body in order to exercise any attractive force.

Bradford[115], at about this period constructed, after considerable experimentation, a magnet consisting of a core of soft Norway iron, one-third of an inch in diameter and two and one-half inches in length. To one end of this solid cylinder was riveted a flat circular disc of the same material, one inch in diameter and one-sixteenth of an inch thick. The core was wrapped with insulated copper wire. Bradford claimed that larger magnets would offer no advantages over his model, of which the suspensive force was twenty ounces. His magnet, however, was intended to be placed in contact with the foreign body and, as he remarks, "their field is no more intense (i. e., larger magnets), and unless the foreign body is of many pounds weight they do not exert any greater force."

Hubbell[116], in 1884, devised a magnet of about the same size as Bradford's but of greater strength. It was 3⅛ inches in length and less than ¾ inches in diameter, or 39 cm. by 17 mm. The core was not of solid iron, but was composed of small soft iron wires twisted together around a larger central wire. The surrounding wires, or the "coil," consisted of four wires, each running from one connecting post

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[112]Sulzer. *Proceedings of the Eleventh International Congress*, Rouen, March 29, 1894.

[113]Snell. *Loc. cit.*

[114]Gruening. On the Removal of Particles of Steel or Iron from the Vitreous Chamber by Means of Magnets. *Med. Record*, 1880, Vol. 17, p. 484.

[115]Bradford. The Electro-magnet in Ophthalmology, with the Description of a New Magnet. *Bost. Med. & Surg. Jour.*, 1881, Vol. 104, p. 292.

[116]Hubbell. The Electro-magnet in Removal of Steel from the Interior of the Eye. *Buffalo Med. & Surg. Jour.*, 1888, Vol. 27, p. 545; also, Foreign Bodies within the Eyeball. *American Text-book of Diseases of the Eye*, etc. Philadelphia, 1899, p. 369.

to the tip and back again to the other connecting post. In this manner a greater attractive force was secured. It was energized by a quart, single-cell, bichromate battery. With the shortest and thickest point it would hold 31 ounces of iron.*

Haab's Magnet. In 1892, at the meeting of the Ophthalmological Society at Heidelberg, Haab[117] presented his *"giant" magnet* which was the most powerful form that had been produced, although the one devised by Schlosser had been manufactured a short time previously and was nearly as large as Haab's. Haab's magnet was designed to overcome the difficulty of bringing the magnet in contact with the foreign body. As is well known, the force of any electro-magnet decreases rapidly as the object is removed from the center of the magnet's pole (the attraction varies inversely as the square of the distance), and this fact made it necessary to closely approximate, if not actually to touch, the tip of any of the small magnets to the foreign body. Haab's idea was to have a magnet of such strength that it would act on the foreign body, even if it should be a very small one, if the point was within an inch, or thereabouts, of the body, and thus obviate the necessity of introducing the tip into the vitreous. Indeed, his plan was to apply the magnet to the corneal center and draw the foreign body forward into the anterior chamber through the suspensory ligament of the lens, from which point it could be removed by an incision at the limbus, thus avoiding any interference with the vitreous through a scleral incision. The instrument could also be used to diagnose the presence of a foreign body. The body of the magnet is a cylinder of soft iron 10 cm. in thickness and 60 cm. in length. The cylinder is provided with a detachable conical point at each end, and is wound with a coil of copper wire at each end, the whole coil weighing 57 kilogrammes. It is supported on a wooden frame 135 cm. in height, which is on rollers, so that the position of the apparatus can be shifted at will. It is run either by a connection with a dynamo or directly from the street current of 110 volts. It is provided with a rheostat, so that the force of the current can be regulated, and has a switch so that the current can be turned on and off as required. Haab now has a switch which he controls with his foot, so that the current may be very quickly cut off should any emergency

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*In Hubbell's original article appear some interesting historical data which he has collected relative to the early suggestions of the use of the magnet for the removal of foreign bodies from the eye. The first was by Fabricius Hildanus, "Opera Observationum et Curationum," 1646. Others were by Milhes, "Observations of Medicine and Surgery," 1745; by Morgagni, "De Sedibus et Causis Morborum," 1779; and by Himley, "Die Krankheiten und Missbildungen des menschlichen Auges und deren Heilung," 1843.

[117]Haab. Die Verwendung sehr starken Magnete zur Entfernung von Eisensplittern aus dem Auge. *Bericht ü. d. Vere. d. Ophth. Gesellesch.*, Heidelberg, 1892, p. 163; also, Ein neuer Elektromagnet zur Entfernung von Eisensplittern aus dem Auge. *Beitr. z. Augenhlk.*, 1894, Heft. 13, p. 68.

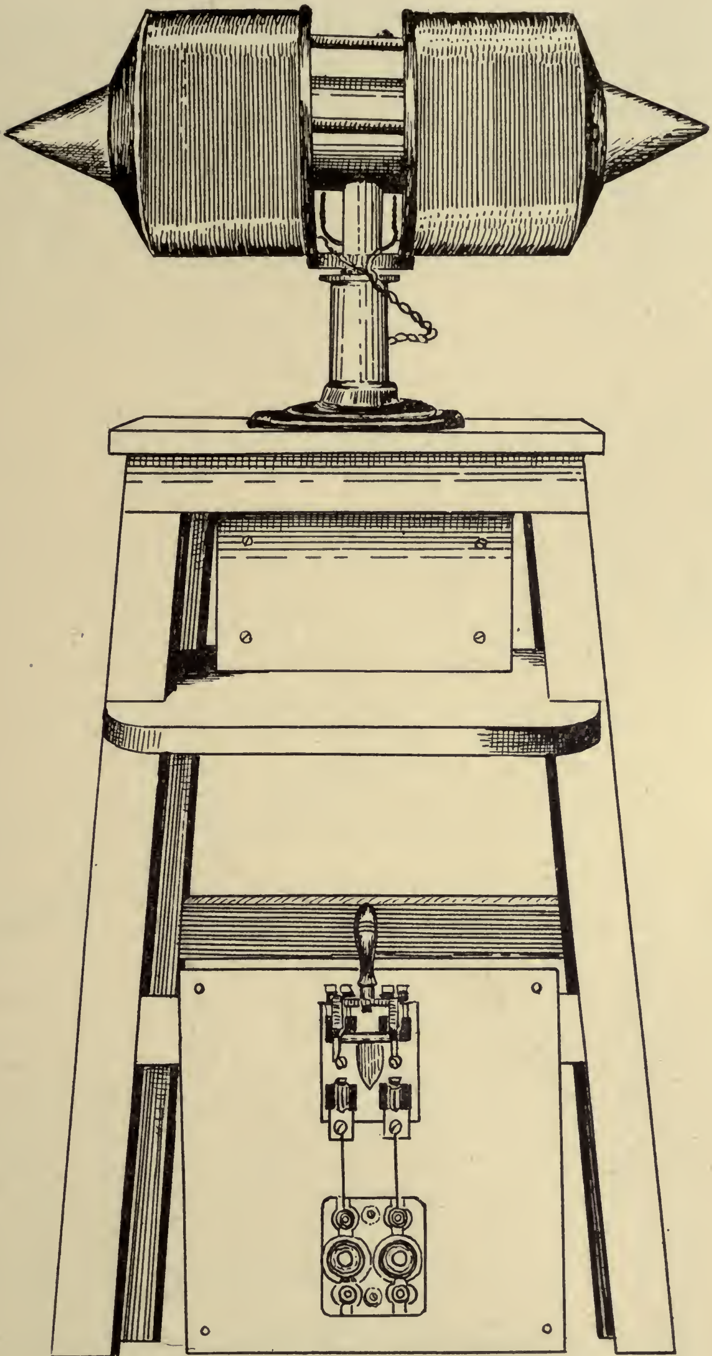

Fig. 113.
Haab's Magnet.

arise. The magnet, in its usual form, is set on a rotatory joint, so that it may be turned around, and further has a joint allowing it to be tilted up and down, so that it may be easily approximated to the eye of the patient as he sits upright before it. It has also been constructed with heavy counterpoise weights, or hung on heavy chains, so that it may be used with the patient in the recumbent position on an operating table.

Schlosser's[118] *magnet* was composed of a central cylinder 13 cm. long and 4 cm. in diameter, wound with a single coil of 500 turns of copper wire. It required a current of 30 volts. Later it was modified so as to be used with a 110 volt current, with 20 to 30 amperes, making its force equal to Haab's model. The mounting was on an adjustable stand of wood, and a circular chin rest was added.

Johnson[119] of Paterson, N. J., devised a powerful hand magnet with internal resistance sufficient to enable it to be attached to the 110 volt current. This magnet is 7½ inches long and is wound with single silk-covered magnet wire, the total weight being 3 pounds, 10 ounces.

Lippincott[120], of Pittsburg, has also devised a magnet which is portable and more easily managed than Haab's, but is much less powerful. This magnet is 12 inches long, 2½ inches in diameter, and weighs nine pounds. It is usually suspended from the ceiling.

Mayweg[121] has devised a magnet which is similar to that of Schlosser but has 1,000 turns of wire instead of 500, as in Schlosser's. It has a screw attachment, so that it may be easily approached to the patient's eye.

Schenkel's[122] magnet is composed of a bar of soft iron 55 cm. in length. The poles are joined to the main bar by a sort of "ball and socket" joint, which permits free movement in any direction.

Sweet[123] has constructed a hand magnet which he has shown by experiment to be considerably more powerful than the Hirschberg. It is 10¾ inches in length, 2½ inches in diameter, and weighs silghtly over 10 pounds. The core is 1½ inches in diameter, one end being rounded and the other tapped to accommodate points similar to the

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[118]Schlosser. Ueber Eisensplitter im Auge. *Munch. Med. Woch.*, 1893, Vol. 40, p. 236; also, Bedingungen zur Entfernung von Eisensplittern durch den Magneten. *Bericht. ü. d. 23, Vers. d. Ophth. Gesellsch.*, Heidelberg. 1893, p. 153.

[119]Johnson. Description of a Portable Electro-magnet, an Original Device, to be used in Connection with any Incandescent Electric-light Current for the Removal of Pieces of Steel from the Interior of the Eyeball. *Archiv. of Ophth.*, 1899, Vol. 28, p. 326.

[120]Lippincott. On the Advantage of Strong, Portable, or Easily Movable Magnets in Eye Surgery. *Trans. Am. Ophth. Soc.*, 1900, Vol. 9, p. 152.

[121]Mayweg. Ueber Magnetoperation. *Klin. Monatsbl. f. Augenhlk.*, 1902, Vol. 40, pt. 2, p. 1.

[122]Schenkel. Quoted by Béal. *Corps étrangérs magnetiques*, etc., p. 52.

[123]Sweet. Foreign Bodies in the Eye. *Jour. Am. Med. Ass'n*, 1902, Vol. 39, p. 467.

Hirschberg. The core, instead of being uniform in diameter, gradually tapers toward the end to which the tips are attached, being elliptical in longitudinal section, the windings of the wire at the tapered end being more numerous than at the rear portion. This method of construction was followed in the belief that there would be secured a more perfect saturation of the pole of the magnet. It is attached directly to the lighting circuit for use.

Volkmann[124] of Berlin has designed a large magnet which differs materially in its construction from those already mentioned. It is composed of a very long bar of soft iron, 95 cm. in length and 5 cm. in diameter. The winding is much thicker at the end which is used for attracting the foreign body, where the diameter of the instrument is 14 cm., while at the other end the diameter is but 10 cm. This method of winding is for the purpose of concentrating the greatest magnetic force at the pole. This force being exceedingly intense and having to make a circuit to the uncovered and comparatively distant pole through a path of air, must occupy a large and elongated sphere of action of which the iron core may be said to be the center, bisecting it through its longest diameter. The circumference of this sphere of magnetic activity ex-

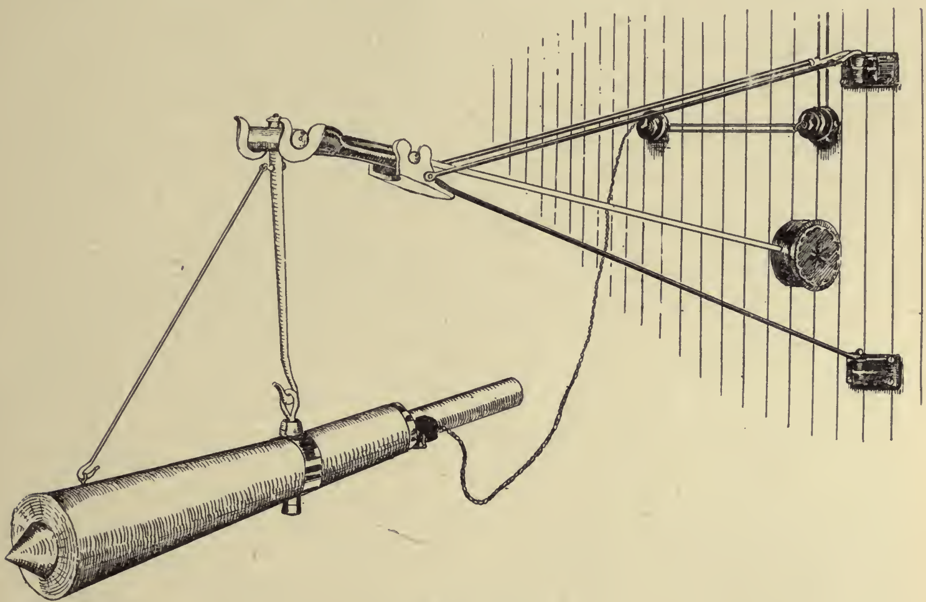

Fig. 114.
Volkmann's Magnet.

[124]Volkmann. Neue Augenmagnete. *Klin Monatsbl. f. Augenhlk.*, 1902, Vol. 40, pt. 1, p. 353; also, Neue Formen meiner Augenmagnete. *Klin. Monatsbl. f. Augenhlk.*, 1903, Vol. 41, pt. 2, p. 217.

tends eccentrically beyond the magnetic poles, and passes close to the unwound end of the core and at an exceptionally great distance from the working pole, giving a far-reaching exhibition of attractive power at the magnet's working point. The body of the magnet is enveloped by a covering of leather and is surrounded by a metal ring by which it is suspended, as is shown in the cut. The working pole is covered by a plate pierced in its center for the attachment of the points. There are three of these—one flat, 15 cm. in diameter, one hemispherical, and one conical. The magnet is balanced upon a rod, on the end of which is placed a movable counterpoise by means of which it can be raised or lowered at will. The suspension apparatus consists of three arms or stays which work in pivotal bearings which are screwed to the wall of the operating room. There are several sizes of these magnets, the weakest of which is for a 6 to 12 volt current, drawing 2½ amperes, while the strongest is for the 110 volt current, drawing 16 amperes.

Volkmann has modified the original form by decreasing the length of the core to 59 cm. and increasing the thickness. The core is uncovered at one end (not the "working" end) for a distance of 14 cm. The current is opened or closed by a foot interrupter. This magnet is undoubtedly a valuable instrument, although little used in America. It is enthusiastically recommended by Béal.[125]

Mellinger[126] has devised a magnet of peculiar shape, which is based upon the principle of solenoids or "ring-shaped" magnets. It is composed of an oval formed by a great number of turns of wire 1 mm. in diameter, which is surrounded by a broad ring of soft iron. At the lower part of the ring is a plate of ebonite upon which the hand of the operator rests. The whole is mounted upon a heavy stand, which insures steadiness. In magnets of this character the attractive force is concentrated in a line parallel to the axis of the "ring." It follows, then, that when the patient's head is placed in the ring we have a force of great attraction at the situation of the injured eye, which is placed in the center of the ring. The operator steadies his hand on the plate of ebonite and uses a magnetized stylet to withdraw the foreign body. The ebonite plate is necessary so that the foreign body will be drawn toward the stylet, and the stylet will *not* be drawn into the center of the ring, towards the eye. Should the stylet prove insufficient, the ebonite plate is removed and a pole of iron in the form of a curved cone or horn is fixed to the situation of the plate, pointing directly at the injured eye. In this way a greater attractive force is secured. This latter pole is used only to detach the foreign body from a firm lodgement in

[125]Béal. Loc. cit., p. 58.

[126]Mellinger. Der Innenpolmagnet. Eine Neue Verwertung des Elektromagnetismus zur Entfernung von Eisensplittern aus dem Auge. *10 Cong Internat. d'ophtal.*, 1904, p. C. 193.

Fig. 115.
Mellinger's Magnet, Showing Method of Use.

the posterior part of the globe. When the foreign body presents back of the iris, the cone-shaped pole is removed and the operation is finished with the stylet, which permits of more accurate control.

Numerous other magnets have been devised, mainly on the Hirschberg and Haab plans of action, but the examples given are the more important, and it is unnecessary to reduplicate.

Comparison of the Strength of Large and Small Magnets. On account of the claims of superior excellence which have almost universally been made by the designers of magnets, some definite data of comparison in strength were early found desirable. Türk[127] has gone over the question very carefully and has made exhaustive tests, in contrasting the Hirschberg and Haab magnets. He found in general that for splinters from 1 to 250 mg. in weight, when the splinter is in direct contact "the power of the Hirschberg magnet is but little less than that of the Haab." At 2 mm. distance from the splinter, however, the Haab magnet is from 7 to 21 times as attractive for splinters weighing 1 to 250 mg. as the Hirschberg, and the more the distance is increased the more favorable are the readings for the Haab. "Beyond 1 cm.," says Türk, "comparison is difficult, since the power of the Hirschberg magnet is so slight, but even at 2.5 cm.—approximately the sagittal diameter of the eye—the Haab magnet attracts a splinter weighing 1 mg. with 13 mg. added weight."

Barkan[128] gives a series of tests which he performed with Hirschberg's old magnet, his later and larger size, and Haab's. He placed two particles of steel on a sheet of smooth paper and measured the distance at which they were attracted to the magnet's point. His results were as follows:

a. Hirschberg's old magnet with chromic acid bottle element, the tip used being the finest of the set and about the same as tip No. 8, attracts particle weighing .000775 g. at ¾ cm., particle .0167 g. at ⅔ cm.

b. Hirschberg's new large hand magnet, with Edison current and rheostat, attracts:

	Particle .000775 g.	Particle .0167 g.
With tip 1 (largest)	at 4 cm.	at 4.5 cm.
With tip 2	at 3.015 cm.	at 4.0 cm.
With tip 9 (smallest)	at 2.25 cm.	at 2.5 cm.

c. Haab's magnet attracts particle .000775 g. at 13 cm.; particle .0167 g. at 16 cm.

Sweet[129] tested the power of his magnet as compared with the Hirschberg and Haab magnets, and found that the Haab magnet was

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[127]Türk. Investigations on Eye Magnets. *Arch. of Ophth.*, 1902, Vol. 31, p. 141; also, Untersuchungen über Augenmagnete. *Archiv. f. Augenhlk.*, 1901, Vol. 42, p. 266.

[128]Barkan. Further Clinical Experience with Haab's Giant Magnet with Some Experimental Statements Regarding Hirschberg's New Large Handmagnet. *Arch. of Ophth.*, 1902, Vol. 31, p. 4.

[129]Sweet. Foreign Bodies in the Eye. *Jour. Am. Med. Ass'n*, 1902, Vol. 39, p. 467.

superior over all sizes of splinters situated 10 mm., or farther, from the magnet. When the splinter is 5 mm. distant, the drawing power of the Haab still remains greater, but the difference in power is not marked. At 2 mm. distance the advantage was with the Sweet magnet, as is shown by the following figures:

	Weight of splinter. Grams. .001	.005	.010	.020	.050
Hirschberg	.076	.275	.773	1.080	2.450
Haab	.064	3.800	5.700	11.000	25.000
Sweet	1.400	4.700	7.750	16.070	41.000

Sweet's method of measurement was to place the magnet with its long axis vertical, the splinter of steel being held in recesses in a soft piece of wood, each recess being at a measured distance from the magnet tip. The holder containing the splinter was suspended from one arm of a delicate non-magnetic balance, the other arm carrying the weights. After the current was turned into the magnet, the weights were added until sufficient force had been added to overcome the magnet's attraction for the splinter at each given distance.

The *Meyrowitz Bulletin* (New York), gives the following comparative tests: "To obtain an exact relative comparison, we have used in this test the same method which was employed by the designer" (Haab) "in testing the original magnet, that is, we have attached to a piece of iron of one gram weight, a thin cord, and to the other end of this cord a receptacle in which weights are placed until the drawing capacity is exhausted. At the same time, we have interposed between the gram weight and the point of the magnet three pieces of wood, of 3, 10, and 15 mm., respectively, and on turning on the 110 volt current the results were as follows:

Haab,
  Wood 5 mm. metal 1 g. supports 337 g.
  Wood 10 mm. metal 1 g. supports 173 g.
  Wood 15 mm. metal 1 g. supports 105 g.
Johnson,
  Wood 5 mm. metal 1 g. supports 48.5 g.
  Wood 10 mm. metal 1 g. supports 20.5 g.
  Wood 15 mm. metal 1 g. supports 9.5 g.
Hirschberg (with three-cell storage battery),
  Wood 5 mm. metal 1 g. supports 10.5 g.
  Wood 10 mm. metal 1 g. supports 2.5 g.
  Wood 15 mm. metal 1 g. no magnetic result.

Taking all these results, together with the results of clinical experience, there seems to be no doubt of the great superiority of the Haab, or other large magnet, in attracting small foreign bodies at a dis-

tance of 5 mm. or more from the tip. Where the tip can be brought within 5 mm. of the foreign body, it is only necessary to use a large magnet if the particle is very small—1 mg. or less. For larger particles or for any particle within 5 mm., the advantages of the hand magnets—Sweet's or Hirschberg's—are very great, in that they are much more easy to handle than the so-called "giant" ones.

Foreign Body Injuries.

Before taking up the question of the magnet operation, it is necessary to speak briefly of some of the general characteristics of penetrating wounds of the eyeball with retention of foreign body. They occur almost exclusively in workmen who, from the nature of their calling, are exposed to this kind of injury. In handling some tool which is of tempered steel, and therefore brittle, a small particle is broken off and, flying with great force, penetrates the tunics of the eye. This occurs most frequently in those who are using hammer and chisel to cut cold metal and is naturally most frequently caused by iron or steel or some magnetizable metal—fortunately for the patient. It does, however, occur from other substances—copper, glass, shot, etc.—which, while they are important and have special bearings, are naturally not germane to the present discussion.

Copper is said by Leber[130] to be very irritating to the tissues of the eye. Haab[131], on the contrary, says: "I have witnessed several cases in which copper splinters could be left in with comparatively little harm to the eye; the removal would have, at any rate, damaged the eye more than their being allowed to remain."

Alloys. At times one meets with certain alloys which decrease the magnetic power of steel to a certain degree. Sweet[132] has investigated this question and finds that the principle ones are chromium, tungsten, nickel, and manganese. Manganese steel is considerably less magnetizable than the other forms, in fact, manganese in any considerable amount deprives steel of its magnetic properties "almost completely" (Sweet), the particles hardly more than adhere to the tip of the strongest magnet. Nickel steel is less magnetic only when large amounts of nickel are used, while the others, chromium and tungsten steel, are not markedly different from the ordinary steel.

Size and Shape of Foreign Bodies. The size of the particles varies greatly, but it is not unusual to find them weighing as little as 5 to 10

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[130] Leber. On Perforating Injuries to the Eye by Morsels of Copper and on Their Treatment. *Trans. 8th Internat. Ophth. Congress, Edinburgh,* 1894, p. 40.

[131] Haab. The Removal of Foreign Bodies from the Eye. *Jour. Am. Med. Ass'n,* 1902, Vol. 39, p. 463.

[132] Sweet. Magnetic Properties of Steel Alloyed with Other Metals *Trans. Am. Ophth. Soc.,* 1905, p. 470.

mg. Particles of less than 2 mg. are rare, although Sweet[133] has reported a case in which the particle measured 1½ by ¼ mm. (weight not given, but probably below 2 mg.), and Callan (discussion) said that the smallest he had ever seen weighed but 1/400 gr. (.000166 g.). Five particles selected at random, from the collection of the Manhattan Eye, Ear and Throat Hospital measured as follows:

½ x 1¼ mm.	0.00417 g.
1 x 2 mm.	0.00833 g.
2 x 2 mm.	0.03333 g.
2 x 3 mm.	0.01666 g.
2 x 12 mm.	0.07915 g.

and this represents about the average, as seen by the writer. Foreign bodies of 50 mg., or over, are to be classed as "large" and the contusion effects are likely to be severe. The shape has an important bearing on both the effect and the significance of the size of the wound of entrance. Frequently the chip is a tiny sector of a sphere; at other times it is irregular; while it not infrequently happens that it is split off in the shape of a long splinter, as in the one above measuring 2 x 12 mm. These long splinters usually fly "end on," like an arrow, perhaps on account of air resistance, and enter the eye by a small puncture which is absolutely misleading unless one has a radiograph as a guide. It has not infrequently happened, before the X-ray diagnosis was available, in using a "giant" magnet for diagnostic purposes, that the surgeon was surprised to find such a shaped splinter, with severe reaction to the magnet, where only a small wound of entrance could be found.

Situation. The firm outer coats of the eyeball—cornea and sclera—offer the most resistance to the entrance of a flying particle, and when once these have been penetrated, the lens alone offers any considerable obstruction. It follows, then, that by far the greater number find lodgment in the vitreous, passing easily through the comparatively spongy tissue of the iris, ciliary body, or choroid. In Sweet's[134] series of 702 examinations there were 359 foreign bodies. Thirty-three were in the lens, 9 were in the iris or posterior chamber, 39 were in the orbit, 3 were in the lid, while 311 were in the vitreous—more than 78 per cent.

Beard[135] says that "it is an established fact that at least 60 to 65 per cent. of the foreign bodies that are driven into the depths of the eyeball come to rest in the vitreous chamber;" and, further, "Experience has proved that 65 to 70 per cent. of the vitreous foreign bodies are magnetic,—i. e., of iron or steel."

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[133]Sweet. *Trans. Am. Ophth. Soc.*, 1909, Vol. 12, p. 128.

[134]Sweet. Third Series of Cases of Injuries from Foreign Bodies Examined by the Roentgen Rays, with Results of Operation. *Trans. Am. Ophth. Soc.*, 1909, Vol. 12, p. 117.

[135]Beard. *Ophthalmic Surgery*, Philadelphia, 1910, p. 621.

Character of the Injury. If the foreign body is large, and particularly if it approaches the cubical shape, the wound of entrance, which is usually in the cornea or limbus, is more in the nature of a *tear* than a *cut* and the contusion effects are apt to be severe. There is usually considerable hemorrhage, lacerations of the uveal coat or of the lens, with perhaps detachment of the retina and prolapse of uvea or vitreous, or both, in addition to a serious wound of entrance. Infection is much more apt to occur with large particles, on account of the size and the greater degree of coolness of the body as it strikes the eye, and the shock to the eye is such that serious inflammation usually follows. Obviously these cases present very little interest to us in the present connection. The foreign body is removed through the wound of entrance by a small magnet with little difficulty, and the eye is usually lost.

In injuries by small particles, however, we have widely varying conditions which require special consideration, and in which much depends upon the technique of the removal of the particle. Small particles are apt to be sterile, or at least to have very limited powers of infection, supposedly on account of the heating which accompanies their forcible splitting from the main mass of metal. However this may be, it is no uncommon thing to find the wound of entrance closed a day after the injury, and the eye relatively free from inflammatory reaction. As is well known, the foreign body may remain encysted or surrounded by exudate, or at least adherent in its position of rest, without giving any sign of its presence for months, or even years, depending somewhat upon its location and the character of the tissue in which it lies, and to this fact is due the most complicated class of cases, i. e., cases in which the wound of entrance has been healed for days, or even longer. In the past, before the methods of localization and removal were so well matured, the question was frequently discussed as to whether it was not wiser to allow a foreign body, that was not causing irritation, to remain, rather than risk the dangers of an operation for its removal.

A movable foreign body is always a menace, and taking into consideration the exactness of the present methods of localization and the improvements in magnet technique, the author wishes to emphatically indorse the remark of Gruening[136], who says: "Because of the tendency to sink and come into contact with the uvea, early extraction of freely movable bodies is advisable."

With *fixed foreign bodies,* lodged in some tissue which does not react to their presence, as in the retina, the question is more difficult. The dangers are those of local degeneration, at times allowing the body

[136]Gruening. *System of Diseases of the Eye.* Norris and Oliver. 1898. Vol. 3, p. 708.

to become detached and movable, siderosis, and acute attacks of inflammation—even sympathetic inflammation in the fellow eye. While exceptionally these ill effects may not occur, the exceptions are few and far between, and the author is always inclined to attempt the removal where it seems probable that the operation will not be a too formidable one.

The immediate effects of foreign body injuries, besides the entrance wound in the cornea or sclera, include wound of the iris, ciliary body, or lens, or perhaps laceration of the iris with prolapse—all in varying degrees, the severity depending on the amount of "contusion" element present in the injury. Hemorrhage is almost always present and, while infection is no less fatal than in injuries with larger particles it occurs much less frequently. However, a certain degree of plastic inflammation is the rule rather than the exception, and when the eye has escaped the immediate dangers of a penetrating wound it is no unusual thing to have a plastic irido-cyclitis come on with such severity as to lead rapidly to phthisis bulbi. If all this has been escaped, we have certain low grade degenerations which are apt to follow as time goes on—contracting cicatrices, degeneration of the vitreous, detachment of the retina, atrophy of the globe—so that the final results are apt to bring the percentages of eyeballs saved down to a rather disappointingly low figure. Take it all in all, an injury with a foreign body in the vitreous is a very serious condition; and but few cases preserve any considerable amount of vision for long periods of time. Besides, the eye which has been wounded is in many instances a fruitful source of irritation to its fellow, even after the foreign body has been removed, during the subsequent inflammation and degeneration.

Diagnosis.[1]

The magnet operation requiring detailed description is in the case of retention of a *small* foreign body, and what follows is written on this basis. Where a wound with a large body exists, we usually see the case soon after the injury, the wound of entrance is still open, and all that can be done is to extract with a hand magnet with as little violence as may be. In the case of a *small* foreign body, where the wound of entrance is perhaps closed, the first step is to have an accurate diagnosis of the presence and size of the particle by means of the X-ray. Much stress has been laid on the time consumed by this, but it is very doubtful if the time sufficient for an X-ray examination—an hour at the most—adds materially to the gravity of the prognosis, and if we are to operate intelligently it is absolutely essential that we be correctly informed as to the location, size, shape, and general roughness of the foreign body. It has too often been demonstrated that to place the patient before a large magnet without this information is productive of some very dis-

agreeable surprises to the surgeon. The magnet, on account of the dangers and uncertainties involved, should no longer be used as a means of diagnosis. If the foreign body should happen to be larger than has been suspected, great damage can be done by the forcible pull of the "giant" magnet. Having this information, we proceed to the

Selection of the Magnet.

This will depend largely upon the size and location of the foreign body, although the route chosen will of necessity have some influence. Very small particles, especially if situated far back, will necessitate the use of the Haab or one of the other large magnets, while the medium or large particles should always be attacked with a small magnet first. The practice of placing patients before the giant magnet without regard to the size of the foreign body, cannot be too strongly condemned as, in the case of a foreign body of any size, it is torn violently from its lodgment, causing much unnecessary damage to an already badly injured eye. Such a proceeding might have had some slight grounds of justification before the use of X-ray localization, when the magnet was used for diagnostic purposes, but at present it can have none. It is scarcely possible, as will be readily appreciated, to meet all the contingencies satisfactorily without having at one's command at least two styles of magnet—a large one, as of Haab, and a small one, as of Sweet or Hirschberg. The more gently the foreign body can be detached from the interior of the eye, the better, and it is even preferable. in the writer's opinion, to introduce a sterilized tip of a Hirschberg magnet into the vitreous, if by so doing we can extract the foreign body, than to tear the foreign body forcibly through the tissues of the eye with the large magnet. This is not to say that insertion of the tip into the vitreous is a proceeding to be advised. On the contrary, it should be avoided whenever possible (which is almost always), although it must be said that in the days when the Hirschberg magnet had to be used to explore the interior of the eye, the traumatism was undoubtedly much greater than at present when our methods of localization are exact.

If, then, we find that the foreign body is small, and especially if it lies far back in the interior of the globe, the large magnet should be selected. Haab's magnet, as before stated, is designed so that it stands upright on a framework of wood, and allows of a tilting up and down of the magnet, so as to alter its position readily. The patient then must be approached to the magnet and the operation, up to the time that the foreign body enters the anterior chamber, must be done with the patient sitting up. To meet this disadvantage, some surgeons use the magnet supported by a steel cable from a crane, with balancing counterpoise weights, so that it is carried over the operating table and the operation

is done while the patient is in the recumbent position. To many surgeons, however, the writer among the number, the risk of handling an enormously heavy piece of apparatus over the patient's head and approaching it gradually to the eye, seems hardly commensurate with the advantages gained. Moreover, the great disadvantage in connection with the use of the Haab magnet is the fact that as the foreign body approaches the tip the force *increases* enormously, just at a time when it should *decrease*. With the greatest possible care, the foreign body will present back of the iris with considerable force, and it is essential to be able at once to stop the dragging. Now, it is manifest, that the patient, in drawing back his head as he feels the pain, will do this much more quickly than can possibly be done by an assistant at the word of command, or even by the surgeon with a foot "cut-off." If the patient is recumbent, he cannot withdraw his head at all. Again, if the patient is recumbent, when the current is cut off the foreign body is apt to slowly sink back into the vitreous, which does not happen if the patient is upright. For these reasons, it is best to follow Haab's method and operate with the patient sitting up. This is the more easily practised in that almost all these patients are workmen and bear the manipulations well. The Haab magnet is used until the foreign body has entered the anterior chamber, when, if an opening exists, the extraction may be completed. As a rule, however, it is better to place the patient in the recumbent position when the operation has reached this stage, and finish with the hand magnet of Hirschberg. If the wound of entrance is in the sclera and is still open, or if for any reason the scleral route should be chosen, the Hirschberg magnet is the better one to use, as the particle may be drawn out much more gently, with the patient in the recumbent position.

The Operation.

The eye, of course, is to be thoroughly cleansed and cocainized, the patient's head covered by a towel and steadied by an assistant, leaving the operator's hands free to manipulate the lids and approach the patient's head to the tip, which is, of course, sterilized. In using the Haab magnet, several points are to be borne in mind: (1) that the attraction is directly proportional to the mass; (2) that the attraction is inversely proportional to the square of the distance; (3) that magnetization and polarization of the foreign body takes place almost immediately, or within a very short space of time. In Haab's earlier writings he insisted upon the importance of placing the point of the magnet first over the center of the cornea so that the foreign body would be drawn away from the ciliary body. With the knowledge that comes from the size and location of the foreign particle, our views upon this point must

undergo a certain modification, and it is undoubtedly better policy to lead the particle directly in the line in which we wish it to go.

It is well, at the beginning, to say that every foreign body case must be a law unto itself, as each presents individual complications and conditions; and it may be said in general that the method of removal which is accompanied by the least traumatism is the best. If the case is seen within the first twelve hours, before the closure of the wound, and the foreign body lies near the wound, it is, of course, the best policy to extract it through the wound of entrance, even if it be in the sclera leading directly to the vitreous. Frequently the foreign body, if in the shape of a spicule, will engage in the margins of the wound, and if the force of the magnet is kept up will only be extracted with a good deal of tearing and damage. This point should be carefully watched for, and if the foreign body engages the current should at once be cut off or the patient's head moved slightly back, and then another attempt made at a slightly different angle. Kipp[137] has suggested that under these circumstances the magnet may be reversed and the other tip used, under which circumstances the foreign body, being polarized, will reverse itself and approach the magnet with its other end. He has himself practised this manœuvre with success. It must be remembered, however, that if the spicule is a very long one, the amount of churning up of the vitreous in the course of this reversal is considerable, and it is probably best under these circumstances not to attempt the manœuvre.

The Anterior Chamber Route. If the wound passes through the cornea and iris, or if the primary wound is healed, wherever it may be, there seems no longer any question but that the removal of the foreign body through the anterior chamber is the most desirable method to use, if possible. Many apparently brilliant results of removal by incision through the sclera into the vitreous have been observed, only to find that a gradual detachment of the retina and total destruction of the eye supervened. The introduction of even a sterile foreign body into the vitreous is a serious blow to the nutrition of the eye, and if we add to it a retinal cicatrix, which will almost invariably undergo connective tissue proliferation and shrink[138], the results cannot be other than fatal to the integrity of the eye. If then, the wound of entrance is closed, our best procedure is through a limbus section with a keratome at a point opposite to the location of the foreign body and as near as possible to any iris lacerations which may be present, so that an iridectomy,

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[137]Kipp. Two Noteworthy Cases of Extraction of Iron from the Vitreous Chamber by Means of the Giant Magnet. A New Procedure. *Archives of Ophth.*, Vol. 31, p. 391, 1902.

[138]See Parsons, The Pathology of the Eye, Vol. 2, p. 547, 1905; also his article on Wounds of the Retina, in *Royal London Ophth. Hosp. Reports*, Vol. 15, No. 3, 1903.

if necessary, may include these lacerations. As a rule, the incision will be downward. The patient is then approached to the end of the magnet, the operator separating the lids and instructing him to look in such a direction that the direct route from the foreign body to the magnet will

Fig. 116.
Method of Using the Haab Magnet.

pass through the zonule, and either through the iris laceration—if that be large enough—or as near as possible to the pupillary margin, if the iris is comparatively undamaged. If the lens be not wounded, it is important to place the line of traction so that the lens will escape laceration. Frequently several attempts will have to be made before the foreign body leaves its lodgment, especially if it is far back in the eye; and if the iris is comparatively undamaged (in which case the path of

the exit cannot be made in a single unbroken straight line) the operator should carefully watch for evidence of the fact that the foreign body has reached the region of the root of the iris, this evidence being either the sensation of pain by the patient or a slight bulging forward of the tissues. *Severe* pain should at once be an indication for cutting off the current or withdrawing the patient's eye from the magnet, on account of possible damage to the ciliary body and iris—the patient being upright, he will draw back quickly. When the foreign body has passed the circumlental space—of course having perforated the zonule, which matters little—and engages the iris, it should then be coaxed upward through the pupil by altering the direction of the patient's gaze, when it may easily be extracted from the anterior chamber—either by a new application of the giant magnet or, what is undoubtedly to be preferred in some instances, by gently coaxing it out with the Hirschberg magnet. If an iridectomy be considered advisable, this can be done either at the time of the section or after the foreign body reaches the posterior part of the iris. In the former case, the procedure is much simpler.

The Operation of Election, then, resolves itself into three applications of the magnet, as shown in Fig. 116. In the first, the magnet is placed below the corneal center, opposite to the foreign body, so as to draw the foreign body into the circumlental space and between the lens and the ciliary body, so that neither is damaged. Its presence will be recognized by pain or dragging forward of the iris. The amount of dragging is a good indication of how to proceed. If the dragging is violent it is better to try a smaller magnet for the remainder of the operation. The second application of the magnet is then made over the upper part of the cornea in an oblique line, so as to conduct the foreign body into the anterior chamber through the pupil. (If the Haab magnet is used, the patient must look down). The third application then suffices to extract the foreign body from the anterior chamber.

Modifications. The fact must be emphasized that although the above method is the most desirable one, and to be used whenever possible, it will be modified by the following considerations:

1. The *wound of entrance is in the sclera and still open.* In this case, it is better to extract directly through the wound of entrance, which is afterwards closed by a conjunctival flap.

2. *The iris is badly lacerated.* An iridectomy is best done before the application of the magnet, which is thereby rendered much simpler.

3. *The foreign body passes through the lens, leaving large masses in the anterior chamber.* This is another indication of more or less weight, depending on the amount of damage done to the lens, for the iridectomy. Lens masses should only be extracted when completely isolated, and the main body of the lens should be disturbed as little as

possible. It is extremely unwise to run the risk of increasing the lens swelling, and it is a good maxim in magnet operations to disturb the lens as little as possible. The reaction will probably be severe enough without any additional lens swelling. Very exceptionally the lens may be so badly broken up that the magnet may be applied directly to the corneal center and the foreign body drawn forward without reference to the lens fragments.

4. *The foreign body is very large or very rough and jagged.* This constitutes an absolute contraindication to the anterior chamber route, as the lens, if clear, may be injured, or the particle may become entangled in the ciliary body and cause serious injury before it can be withdrawn, if, indeed, it does not become firmly fixed. It is better in such cases to choose the scleral route and chance the consequences of the retinal injury.

Difficulties in the Operation. 1. *The foreign body may be so far*

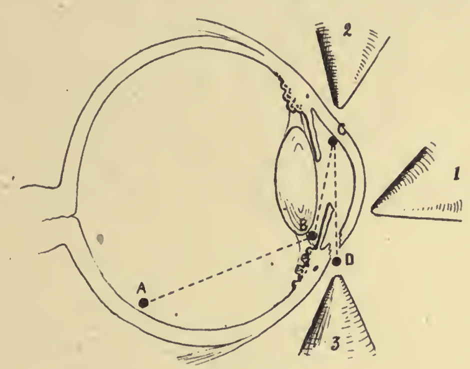

Fig. 117.

Method of Election in Removing Foreign Bodies from the Vitreous with the Magnet. (a, Primary position of the particle; b, Position behind the iris after the first application of the magnet; c, Position after the second application; d, Exit after the third application; 1, 2, and 3, first, second, and third, positions of the tip.)

back and so small that only feeble power can be exerted. In this case it is better to persist in the application of the magnet over the cornea until convinced that it is useless. This can be determined only after numerous applications, for very feeble attraction will sometimes dislodge the particle only after five or six, or even more, applications. It is also good practice to put the patient in the correct position and then turn the current off and on a number of times, so that the particle is acted upon by a series of jerks. Frequently after this manoeuvre we shall be rewarded by finding that the foreign body has reached the posterior surface of the iris—as shown by pain or bulging of the iris—when the patient is allowed to withdraw his head from the magnet, which he will usually do at once. No time should be lost in the succeeding application, so that

the particle will not fall back, and herein lies the advantage of having the incision made before the magnet is applied. The only disadvantage is that if we fail to remove the foreign body we have made a useless incision, but in such cases the condition of the eye is so serious that it may be doubted if the incision makes it much worse. Of course, a useless incision is to be avoided, but if we weigh the probabilities carefully we shall not often fall into this error. If the corneal application fails to dislodge the foreign body the point should be placed in the lower cul-de-sac at a point as near as possible to the foreign body, having the patient look up, and then when the bulging shows that the particle is near the tip, the magnet should be carefully withdrawn and applied over the cornea as before. It is a great mistake to hold the magnet near and sweep it up to the wound without withdrawing it, as in that case the ciliary body will surely be damaged to a greater or less degree—to say nothing of the retina.

2. *The foreign body is in the form of a long spicule, and entangled in the ciliary body or iris.* In this case a smaller magnet should be used at different angles, so as to dislodge it, and any increase of the pain should be the signal for immediate withdrawal of the magnet. If the foreign body becomes so firmly entangled in the iris that it cannot be removed, an iridectomy should be done. Entanglement in the ciliary body usually means rapid destruction of the eye through hemorrhage or inflammation.

3. *The foreign body is surrounded by new-formed tissue which holds it firmly in position.* In this case we shall have the history of the injury a week or more preceding, and though the skiagram shows the particle, the application of the magnet is not attended by pain. It is well to remember that these conditions may obtain even when the foreign body lies on the ciliary body. Enucleation is almost invariably necessary—if not at once, very shortly—nor is it wise to wait long, on account of the danger of sympathetic inflammation.

Various expedients have been devised to meet this difficulty, of which the most direct is to cut down upon the body through the sclera and place the pole of the Haab magnet as near as possible to the body, although for this purpose the Sweet magnet is probably a better instrument.

Risley[139] advises this method in its entirety, in every case—that is, after exact localization with the X-ray, he incises the sclera as near as possible to the location of the foreign body and then inserts the point of the Hirschberg magnet between the lips of the wound and withdraws

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[139]Risley. The Extraction of Metallic Fragments from the Vitreous Chamber. *American Medicine*, 1902, Vol. 4, p. 414.

the foreign body. Leartus Connor[140] reports the use of a strabismus hook for this emergency which is connected with the end of a giant magnet and then inserted into the wound so as to be brought into contact with the foreign body. The author practiced this manœuvre as early as 1897, and it is undoubtedly effective, but is, after all, only making the best of a very bad matter, and the results are not particularly pleasing. Jackson[141] describes two cases in which he used a pair of scissors in the same way. The scissors were introduced into the wound, and the pole of the magnet was placed in contact with the joint. Four or five short snips were then made so as to free the foreign body, and the scissors were withdrawn, bringing the foreign body with them. This was done in each case with good results. Land[142] uses a steel spatula, connected with the Haab magnet by a flexible cable, to complete the removal of the foreign body after it has entered the anterior chamber.

The great disadvantage with all these devices is, that any kind of "extension point" removes the working point from the center of the magnet's activity and thus enormously decreases the magnet's power. These "extension points" must be brought into direct contact with the foreign body to be at all effective.

The Scleral Route. Many ophthalmologists believe that it is always simpler and better to remove a foreign body, which lies in the vitreous, by a scleral incision. In fact, this was the oldest method, and was used by McKeown and also by Hirschberg, although they introduced the tip of the magnet into the vitreous and searched in various directions for the foreign body. This was productive of much disturbance in the nutrition of the vitreous, and was strongly condemned by Haab in his earlier writings—in fact, the "giant" magnets were all devised so that the foreign body could be brought into the anterior chamber, and the vitreous disturbed as little as possible. With the development of more accurate methods of X-ray localization, however, it became possible to incise the sclera so close to the foreign body that the tip of a hand magnet had only to be inserted between the lips of the scleral wound to secure the particle, and entrance into the vitreous was not necessary. Risley advocated this procedure in the discussion of Haab's paper at the meeting of the Ophthalmological Section of the American Medical Association in 1902, and published the above mentioned paper in the September following.

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[140]Connor. The Giant Magnet in Ophthalmic Surgery. *Jour. of Am. Med. Ass'n,* 1903, Vol. 40, p. 772.

[141]Jackson. Scissors-magnet Extraction of Iron from Eyeball. *Jour. of Am. Med. Ass'n,* 1909, Vol. 52, p. 1985.

[142]Lang. A Note on the Use of Haab's Magnet. *Royal London. Ophth. Hosp. Rep.,* 1903, Vol. 15, p. 296.

De Schweinitz[143], three years later, reported twenty-six cases of foreign body injury and strongly advocated the method, which he believed simpler and safer than the anterior chamber route.

The operation is at present performed as follows: After accurate X-ray localization of the foreign body, the patient is placed upon the operating table and the eye prepared as for any important globe operation. Cocaine anesthesia is usually sufficient, though at times ether narcosis may be better. The conjunctiva is first incised in the location of the foreign body and the sclera bared, avoiding as much as possible the recti muscles. Then an incision over the foreign body is made directly through sclera, choroid, and retina, as cautiously as possible and in a meridional direction—that is, parallel to the recti muscles, as suggested by Risley—for the reason that such wounds bleed less than those which cut across the choroidal vessels, and gape less, on account of the fact that the pull of the recti muscles does not open them. The tip of a magnet—one of the small magnets, Sweet's or Hirschberg's—is inserted between the lips of the wound, and usually the particle can be withdrawn with ease. Should the foreign body fail to come away, the magnet must be inserted with great care, so as to come as closely in contact with the particle as possible. Afterward, the wound is closed with a catgut suture, the conjunctival flap brought over it so as to close it firmly, and the operation is done. J. Herbert Fisher[144] inserts two episcleral stitches, cuts between, and has an assistant hold them during the operation, after which they are tied.

Comparison of the Two Routes. At the present time, in the United States, a decided difference of opinion exists as to which is the better method to be chosen in cases where the wound of entrance has become firmly closed. The advantage of the scleral route is mainly in the ease with which the removal of the particle is accomplished, and the consequent lack of traumatism to the eye. Its advocates lay great stress on the dangers of entangling the foreign body in the ciliary body, the undesirability of a second excursion of the particle through the vitreous, the dangers of further wounding the lens, and finally, the violence apt to be done the eye by the use of the "giant" magnet. Its disadvantages are: the danger of infection by exposure of the vitreous, the great probability of a certain amount of choroidal hemorrhage, and, finally, the liability of subsequent retinal detachment and degeneration of the globe through the interference with the vitreous and the presence of the retinal cicatrix.

The anterior route is more difficult, technically, but is undoubtedly

[143]De Schweinitz. Metallic Foreign Bodies within the Eye, and Their Removal; Being a Clinical Account of Twenty-six Operations of this Character. *Am. Jour. of Ophth.*, 1905, Vol. 22, p. 97.

[144]Fisher. Personal Communication.

safer if the magnet is properly used. The wound in the limbus heals with less disturbance and no subsequent dangers, the dangers of infection are much less, and danger of retinal detachment is in a great measure avoided. As to the wounding of the surrounding structures by the magnet operation—this is almost always the result of improper technique. With a knowledge of the size and location of the particle, it should be possible to bring it forward with the Haab magnet without damage to the surrounding structures. It is not always possible to avoid an iridectomy, but this is not a serious matter. It should, of course, be said that a very large or very rough foreign body should not be dealt with by the anterior chamber operation, for it is manifestly impossible to avoid entanglements in this case, but as most foreign bodies are small and smooth, it follows that the anterior chamber route is almost always available. The advocates of the scleral route deny the greater liability of retinal detachment, but this is against all our knowledge of the pathology of retinal wounds. It must be remembered that it is difficult to follow up this class of patients for very long periods, and convincing statistics are lacking on both sides. The writer is convinced, however, that enough cases have been observed by competent authorities to make it certain that detachment occurs more frequently than is generally supposed, though it probably comes on very slowly and only after a lapse of months, or even years in certain instances. Snell[145] says that "we know from the interesting investigations of Parsons that in the healing of sclerotic wounds the injurious effects are observed in the underlying tissues for some distance around. Experience therefore has led me to believe that in many instances the anterior route should be selected."

In the discussion of Haab's[146] paper this question was touched upon. Haab believed in interfering with the vitreous as little as possible. Knapp[147] had seen a case in which, three or four months after the scleral operation, detachment had occurred, and thought a scleral incision should be avoided, Holt[148] had observed a series of cases but had not seen detachment. Hiram Woods[149] had seen a case of detachment six weeks after a scleral operation. Sweet[150] spoke of 57 cases reported to the American Ophthalmological Society in 1901. A large number of these had been watched for a considerable time after the magnet oper-

[145]Sneil. The Electro-Magnet in Ophthalmic Surgery. *The Ophthalmoscope*, February, 1905, p. 65.

[146]Haab. The Removal of Foreign Bodies from the Eye. *Jour. Am. Med. Ass'n*, 1902, Vol. 39, p. 463.

[147]Knapp, p. 471.

[148]Holt, p. 472.

[149]Woods, p. 473.

[150]Sweet, p. 473.

ation. Three cases of detachment occurred. The Hirschberg magnet had been employed.

Discussion.

In order to ascertain somewhat the feeling of a representative group of American ophthalmologists on the question of "route," the author sent out fifty personal letters of inquiry, mainly to those whose work and reputation warranted them in speaking with authority on the subject. No attempt was made to secure *all* opinions that would have been of value, as such an inquiry would have been too cumbersome to report. The results seem to show a fair division of opinion on the subject.

Those who favor the anterior chamber route are:

Alling, New Haven.—Does not like vitreous disturbance in scleral route.

Callan, New York.—Has noticed "many retinal detachments as a result of opening the sclera, owing to subsequent contraction and incarceration of membranes about the wound." See Foreign Bodies in the Eye. *Med. Review of Reviews*, April, 1905.

Cheney, Boston.—Only in case foreign body is in anterior part of vitreous and lens has been wounded. If any danger to ciliary body, prefers scleral route.

Gruening, New York.—If lens is clear, uses scleral route.

Johnson, Paterson, N. J.—Scleral incision is more apt to be followed by inflammatory complications.

Kipp, Newark.—Many cases operated on years ago by scleral incision have shown retinal detachment later. In cases where lens is clear and wound closed, tries anterior chamber route, and only uses scleral route when anterior chamber route fails.

Knapp, A., New York.—Endeavors "by all means to avoid a scleral incision" as it leads "generally to detachment and loss of the eye."

Lambert, New York.—Loss likelihood of vitreous hemorrhage.

Weeks, New York.—If foreign body is small, "traumatism to eye is less and prognosis regarding vision and integrity of the eye is much better"; if foreign body is large, uses scleral route.

Wilmer, Washington.—Much simpler to use original wound if possible.

Casey Wood, Chicago.—Always uses the anterior chamber when it is reasonably possible.

Those who favor the scleral route, are:

Beard, Chicago.—Except where foreign body is clearly visible with ophthalmoscope, in which cases prefers anterior chamber route.

Bull, New York.—Unless X-ray locates foreign body too far back thinks less violence is done and believes traumatism in magnet operation is "the main cause for the very general bad ultimate results."

De Schweinitz, Philadelphia.—Thinks it the simplest method and results "just as good as any other." See also Report of Twenty-six Cases, in *Am. Jour. of Ophthalmology*, April, 1905.

Hansell, Philadelphia.—"Because it is a slight operation not followed in my experience by detachment of the retina or other disaster, and involves no danger to structures in anterior part of the eye."

Holmes, Cincinnati.—"With accurate localization, operation presents less chance of intra-ocular hemorrhage and wounding of vital parts."

Howe, Buffalo.—Follows most direct route, usually through the sclera.

Hubbell, Buffalo.—Makes incision to reach foreign body in most direct manner; scleral incision preferred when practicable.

Jack, Boston.—Much less damage both at the time and subsequently.

Marple, New York.—If foreign body is small, particularly if lens is uninjured, prefers scleral route as more direct.

Oliver, Philadelphia.—Least amount of traumatism and best results.

Posey, Philadelphia.—Uses scleral incision as near foreign body as possible, and small magnet.

Randolph, Baltimore.—Always makes scleral incision.

Risley, Philadelphia.—Thinks operation simpler and safer, with knowledge of exact position by X-ray, which makes introduction of magnet tip into vitreous usually unnecessary. (See also paper quoted above.)

Shoemaker, Philadelphia.—Prefers to have line of traction "at right angles" to the fundus or that part of fundus in which foreign body lies, so as to avoid dragging it over retina or any other tissue. Scleral wound heals more quickly and is safer.

Sweet, Philadelphia.—Thinks anterior chamber route dangerous and has "never seen any serious effect follow the scleral incision." (See *Trans. Am. Ophthalmological Soc.*, 1909, p. 117.)

Theobald, Baltimore.—Prefers scleral incision and Sweet magnet.

Webster, New York.—Less traumatism than by dragging foreign body between lens and ciliary body.

Woods, Baltimore.—Less traumatism than by anterior chamber route.

Several letters could not be classified by any distinct preference.

Davis, New York.—Depends upon position and size of object, which route he follows. In all early cases with medium foreign body, by anterior chamber route; larger ones, by scleral route.

Fridenberg, New York.—Large bodies by scleral incision; smaller ones by corneal. Somewhat larger bodies, that are situated far forward, by anterior chamber route.

Wilder, Chicago.—Has had good results with small bodies by anterior chamber route, but thinks with localization a larger body, particularly if sharp or jagged, can be more safely removed by scleral route. Will probably use scleral route in future, with accurate localization, particularly if body is large and irregular.

Ten had no definite opinion, and the remainder were unanswered.

An inquiry was also made as to the question of using the magnet with the patient recumbent or sitting up. No very definite custom seems to exist. As a rule, however, the Haab magnet is used with the patient sitting up; the smaller hand magnets, with the patient lying down.

Results of Magnet Operations.

In dismissing the subject, it may be as well to give some of the principle statistics of the results obtained, although it must be remembered that most of the successful results of foreign bodies removed from the vitreous are open to question, as to the length of time the eye will last without further degeneration. An injury to the vitreous by penetration of a foreign body is a very serious matter, the full consequences of which do not manifest themselves in a month or a year after recovery from the immediate effects. Cases leave us with floating opacities, ciliary or retinal cicatrices, plastic membranes in the ciliary region, etc., which are but too apt to undergo further degeneration. However, the question is assuming much more favorable proportions with the improvements in X-ray localization and magnet technique, which latter is undoubtedly of the greatest importance. The greatest difficulty at present is our almost total lack of knowledge of therapeutic measures connected with the vitreous, with which to supplement surgical procedures.

The failures in this class of cases are certainly discouragingly numerous as compared with the "successes."

Haab[151] reported 165 cases of foreign body in the globe. The entrance was corneal in 133, scleral in 17; the operation failed in 23; was successful in 141 (86 per cent). The eye was removed because of purulent inflammation in 39 cases; because of lingering cyclitis, in 9. 19 sightless eyes were preserved. In 71, the eye could be used or could be made use of, through a cataract operation; and 51 of these 71 healed with "good sight."

Béal[152] gives the folowing series of "vitreous cases":

Results unknown	2
Atrophy of globe	3 (17.64%)
Enucleations	6 (35.28%)
Quantitative perception	3 (17.64%)
Good vision	2 (11.76%)
Feeble vision	2 (11.76%)
	18

Hürzeler[153], 313 cases.

Extraction successful	64.85%
Some vision saved	22.04%
Enucleation or phthisis	50.00%
Globe preserved	17.24%

Hidlebrand[154], 322 cases;

80 in anterior segment:

Suppuration in	16.25%
Good results	83.75%

248 in posterior segment:

Of these, extraction was possible in 174 (70.16%).

Of these 174:

Phthisis	13%
Enucleation	15%
Some vision in	36%
Globe preserved in	16%

Hildebrand[155], second Series. 66 cases, 51 in the vitreous.

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[151]Haab. The Removal of Foreign Bodies from the Eye. *Jour. Am. Med. Ass'n*, 1902, Vol. 39, p. 463.

[152]Béal. Corps étrangers magnétiques, 1908, p. 102.

[153]Hürzeler. Ueber die Anwendung von Elektromagneten bei den Eisensplitterverletzungen des Auges. *Beitr. z. Augenhlk.*, 1894, Heft 13, p. 20.

[154]Hildebrand. Béal. Corps étrangers magnétiques. 1908, p. 102.

[155]Hildebrand. Magnetoperationen mit erfolgreicher Extraction von 53 Eisensplittern aus dem Augeninnern. *Arch. f. Augenhlk.*, Vol. 23, p. 278, 1891.

Extraction was possible in 38.

Enucleation	2 (5.26%)
Phthisis	7 (18.42%)
Globe saved	7 (18.42%)
Good vision	16 (42.10%)
Light preception	6 (15.78%)
	38

Coppez[156],

33 bodies in the vitreous.
28 extracted.

Vision ⅔	1 (3.57%)
Light perception	2 (7.14%)
Globe saved	5 (17.85%)
Enucleation	20 (71.42%)
	28

Mayweg[157].

72 foreign bodies in the posterior segment.

Enucleation	12.40%
Globe preserved	36.03%
Counting fingers	15.17%
Good vision	36.40%

Sweet[158]: 157 cases of foreign body in eyeball or orbit operated on by various surgeons of the Will's Hospital. Of these, 25 were in the orbit and 20 were in the lens, iris, and anterior chamber, leaving 112 in the posterior segment. 86 of these results of steel in vitreous are given, having been observed for more than six months in every case.

Vision = 6/12 or better	24
Vision = less than 6/12	62
	86

Snell[159] gives his statistics from 1896 to 1903:
Foreign body in vitreous or retina, 64 cases (out of 3,018 patients).
"Good and permanent vision," 36 (56%).

Vision = ½ to 1 (out of the 36),	23

[156]Coppez. *Soc. Fr. d'Oph.*, 1890, May 5.

[157]Mayweg. Ueber magnetoperationen. Klin. *Monatsbl. f. Augenhlk.*, 1902, Vol. 40, pt. 2, p. 1.

[158]Sweet. Third Series of Cases of Injuries from Foreign Bodies Examined by the Roentgen Rays; with Results of Operation. *Trans. Am. Ophth. Soc.*, 1909, Vol. 12, p. 117.

[159]Snell. Some Practical Remarks on Magnet Operations. *The Ophthalmoscope*, February, 1905, p. 52.

One-third were operated on with a small magnet; two-thirds with hand and giant magnet together.

Bull[160] reports the post-operative history of 18 vitreous cases;

Removal successful	17
Phthisis bulbi	6
Sympathetic ophthalmia	8
Enucleation	10

"Permanent useful vision was not gained in a single case."

Callan[161] reports 22 vitreous cases:

Total loss	6
20/20	1
20/30	2
20/50	1
20/70	1
20/100	1
"Good vision'	1
Occluded pupil	2
Thickened capsule	1
No report	6
	22

[160]Bull. The Post-Operative History of Eighteen Cases of Magnetic Foreign Bodies removed from the Eye by the Haab or Giant Magnet. *Trans. Am. Oph. Soc.* 1910, Vol. 12, p. 365.

[161]Callan. Discussion of Bull's paper above mentioned. *Trans. Am. Oph. Soc.* 1910, Vol. 12, p. 375.

CHAPTER V.

ANESTHESIA, LOCAL AND GENERAL, IN OPHTHALMIC OPERATIONS.

By WENDELL REBER, M. D., Philadelphia, Pa.

General Anesthesia—Inhalation Anesthesia—Ether—Disadvantages of Ether Anesthesia from the Ophthalmic Standpoint—Ether Inhalers—The Use of Chloroform in Opthalmic Operations—Ethyl Chloride—Ethyl Bromide —The Use of Somnoform—Nitrous Oxide —The Teter Apparatus—Scopolamin-Morphia Anesthesia—Preparation of Patients for General Anesthesia—Local Anesthesia in Ophthalmic Operations—Ganglion Anesthesia—Intraorbital Anesthesia—Nerve-trunk Regional Anesthesia—Paraneural Anesthesia—Technique of Infiltration or Intracutaneous Anesthesia—Various Methods of Securing Infiltration-Anesthesia With Cocaine—Substitutes for Cocaine in Infiltration Anesthesia—Comparative Value and Actions of Various Other Local Anesthesia Agents—Stovain, Alypin, Novocain, Tropacocain, Nirvanin and Beta-Eucain Lactate—Quinine and Urea Bimuriate—Carbolic Acid—Freezing Mixtures—Mucous Anesthesia—The Most Reliable and Least Irritant of the Agents Employed for this Purpose—Cocain and Holocain—Their Advantages and Disadvantages—Substitutes for Cocain—Tropacocain—Stovain—Acoin—Yohimbin—Frynin—Aneson—Oil of Guaiac—Receptacle for Sterile, Local Anesthetic Solutions.

GENERAL ANESTHESIA.

Inhalation Anesthesia.

Prior to 1846, ophthalmic operations were performed without any form of analgesia whatsoever. The result of the operation turned largely upon the marvelous swiftness and dexterity in operating possessed by the ophthalmic surgeons of that time. But Morton's demonstration, in Boston in 1846, at the Massachusetts General Hospital made modern narcosis possible and the ophthalmic surgeon of today may choose his agent for general anesthesia or narcosis from the following list: Ether, chloroform, ethyl chloride, ethyl bromide, nitrous oxide, somnoform and, lastly, scopolamin-morphin, either alone or in combination with ether or chloroform.

The question has been raised as to whether *anesthesia* or *narcosis* should be the term applied to loss of sensation induced by whatsoever method. We prefer to retain the term anesthesia, first coined by Oliver

Wendell Holmes in 1846. Various qualifications of the term easily follow, *e. g.*, inhalation anesthesia, infiltration anesthesia, local anesthesia, regional anesthesia, mucous anesthesia, etc.

There is a certain group of ophthalmic operations that will probably always be done under some form of general anesthesia—such as iridectomy for glaucoma, exenteration, evisceration, enucleation (although many enucleations are today being performed under local or regional anesthesia) plastic lid operations, orbital and orbito-sinus explorations, operations on nervous patients and on children.

The choice of an anesthetic is more or less a matter of caprice with each individual surgeon but we will consider the list just mentioned seriatim.

Ether.

Among general surgeons the country over ether is today probably the anesthetic of choice, especially for prolonged surgical interventions and for abdominal operations, largely because of its relative safety and the familiarity of the general profession with its proper administration. This is evidenced by the report of the Committee on Anesthesia presented to the 1910 meeting of the American Medical Association,* to whom was entrusted oversight of the research on the best anesthetic to use under varying morbid conditions. They insist on the wide distinction between anesthetics proper for use by the general practitioner and anesthetics employed by experts. They finally recommended that for the general practitioner and for all anesthetists not especially skilled, ether, administered by the open or drop method should be the anesthetic of choice, and that the use of chloroform, particularly for so-called minor operations, should be discouraged unless given by an expert. Hare[1] observes that there is probably only one state which distinctly contra-indicates a general anesthetic, namely diabetes mellitus, in which diabetic coma nearly always ensues.

Disadvantages of Ether Anesthesia from the Ophthalmic Standpoint.

From the standpoint of the ophthalmic surgeon, ether has some marked disadvantages, chief of which is the vomiting that so frequently follows its use. The straining that goes with the vomiting may be fraught with the direst consequence as far as the eye is concerned. We have knowledge of several cases in which there occurred a large intraocular hemorrhage during the vomiting following etherization for cataract extraction in nervous individuals.

Next to this objection in importance is the possibility of the vomitus reaching the field of operation and infecting it, which is always a nasty complication at best. There is also the weighty objection that

Jour. Am. Med. Assn., June 11, 1910.
[1]Keen's *System of Surgery*, Vol. V, 1910.

with any inhalation anesthetic the anesthetist and gauze are very much in the way of the operator; and, not infrequently, the anesthetist inadvertently allows the anesthetic to drop or flow into the patient's eye. This has happened several times in our experience.

To avert both difficulties, numerous extension masks have been devised; of which *Lefever's* (Fig. 119) is quite as good as any we have seen.

The claims of this inventor are, 1, that it removes the anesthetist from the field needed by the operator and his assistant; 2, that it assures an aseptic field, 3, that it does away with the ether fumes that often rise in the operator's face, 4, that it lessens the amount of ether used; 5, that the breathing of the patient is perfectly registered by the continual movement of the light aluminum valve, so that the surgeon

Fig. 118.

How the Anesthetist may Interfere with the Manipulations of the Ophthalmic Surgeon.

may always know just how the patient is breathing without asking the anesthetist.

All these claims we endorse from personal use of the device, with the exception of No. 2. No operator can ever be absolutely sure that any patient may not vomit during the operation, no matter what the anesthetic agent may be.

Miller's[2] *apparatus,* (Fig. 120) we have also used but we do not look upon it with as much favor as Lefever's.

Finally, we are obliged to consider the objections brought forward recently by Crile,[3] who in discussing the effects of ether on the vital forces, contends (a) that it contributes to post-anesthesic depression and (b) that it impairs immunity.

[2]Miller. *Jour. Amer. Med. Asso.* Vol. LIII.
[3]Crile. *South. Med. Jour.*, Jan., 1910.

The generally accepted statistics at the present writing indicate one fatality in 16,000 from ether. It is our own feeling that if all the circumstances surrounding many cases that die within 24 to 48 hours of operation were searchingly analyzed, the corrected mortality percentage would be much higher.

The Use of Chloroform in Ophthalmic Operations.

In most of the large Continental and British clinics, choloroform is still resorted to largely for inhalation anesthesia when a general effect is needed. In this country, however, a strong sentiment against chloro-

Fig. 119.
Lefever's Device to Permit the use of a General Anesthetic and at the same Time Afford the Ophthalmic Surgeon the Greatest Possible Free Field.

form has sprung up in the last few years, due perhaps to the insistence of the Eastern schools on the danger of chloroform. The statistics quoted by H. A. Hare[4] are as follows:

Chloroform	1 death in	2,500
Ether	1 death in	16,000
Nitrous oxide	1 death in	200,000

Hare, *(loco. cit.)* goes on to say, however, that there are times when chloroform, because of its known physiologic effects, is often the agent of election, as in arterial spasm with high tension and car-

[4]**Hare.** ***Keen's System of Surgery,*** **Vol. V. 1910.**

diac hypertrophy. Also in nephritis, new or old, it is the drug of choice in most instances. He pleads for the most careful examination of the urine and the circulatory apparatus before administering any inhalation anesthetic. When it is remembered that the average ophthalmic operation seldom requires more than 20 minutes for its performance, it can be readily understood why many ophthalmic surgeons who enjoy the services of an expert assistant, prefer chloroform for their

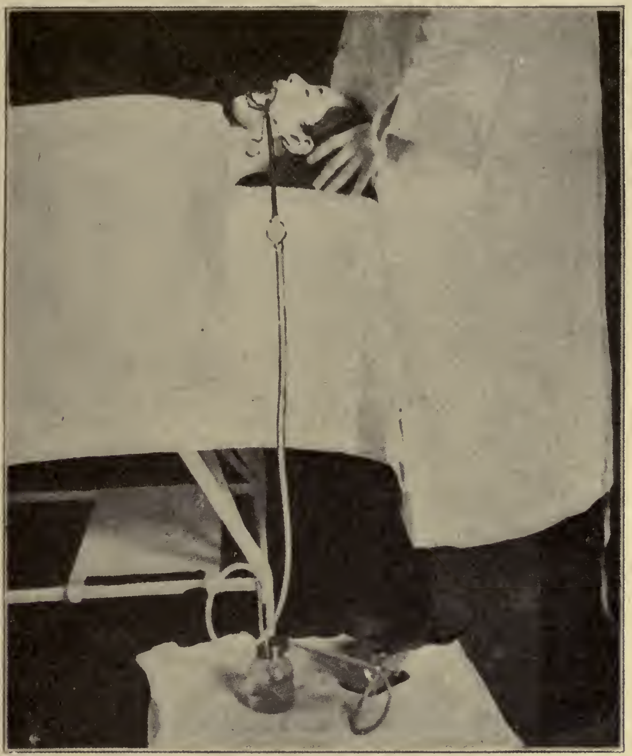

Fig. 120.
Miller's Apparatus to Remove the Anesthetic from the Field of Operation.

operative work. So high an authority as Haab[5] has urged that inhalation anesthesia should be used very little in ophthalmic surgery because of his conviction that local anesthesia whenever in any way possible, is much to be preferred by reason of its safety. Chaldecott[6] agrees with Haab that it is not justifiable in minor eye operations to take the risks of chloroform, yet he thinks that "when anesthesia is induced by gas or ether, and continued by chloroform, the risk in skillful hands is

[5]Haab. *The Ophthalmoscope*, Feb., 1905.
[6]Chaldecott. General Anesthesia in Ophthalmic Surgery; a Criticism. *The Ophthalmoscope*, Aug., 1905, p. 386.

so infinitesimal that it is not worth taking into account." Just why ether should be used to induce anesthesia that is to be continued under chloroform does not appear clear to us—but Chaldecott's view simply emphasizes what we have previously said, that the choice of an inhalation anesthetic is today (and in all likelihood will continue to be) largely a matter of caprice with each individual surgeon. There is no gainsaying the fact that it is well for a surgeon or his assistant to become expert with some one form of inhalation anesthesia and to hold fast to that method as the safest for him and his staff.

The Use of Ethyl Chloride Anesthesia in Ophthalmic Operations.

Within the last decade ethyl chloride has been heralded several times as the agent that would solve the problem of general anesthesia for the ophthalmic patient. But the testimony as to its safety and efficiency is very conflicting. In some of the British clinics it has largely replaced nitrous oxide and to some extent chloroform. Hird[7] claims for it rapid anesthesia, quick recovery and slight after-effects and believes its use will steadily increase. He reports one case of death from it, but it must be admitted that the patient could hardly have been in a worse condition for the use of *any* inhalation anesthesia. He was a man of 67, suffering from epithelioma of the cheek with a swelling in the neck, causing severe dyspnea and general distress; to relieve which the operation was undertaken. Kayser[8] says that among 16,000 narcoses thus induced this is the only fatal case; and although it has been but little used in Germany, he strongly recommends it.

Because of the fatalities attending the use of chloroform for ophthalmic operations, Gendron and Servel[9] have resorted to ethyl chloride, followed by chloroform. About 3 cc. of the ethyl chloride are placed in a rather small, close cone and more added, (how much not mentioned) until general anesthesia is produced, when the change is quietly made to chloroform. Absence of the stage of excitement, less chloroform and diminished unpleasant effects seem to them the advantages of the combination. We can see no reason why chloroform alone would not be as efficient as the foregoing combination. And as to ethyl chlroide alone, we have seen one person so near death's door under the influence of ethyl chloride (and that in the hands of a very careful anesthetist) as to make us forever apprehensive of it.

Ethyl Bromide has been used instead of the chloride by some on the

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[7]Hird. *The Ophthalmoscope*, Mar., 1906.

[8]Kayser. Aethylchlorid und andere Anesthesien. *Klin. Monatsbl. für Augenblk.*, Sept., 1905, p. 300.

[9]Gendron. De l'anesthésie combinée, par le Chlorure d'ethyle et le chloroforme, appliquée a la Chirurgie Oculaire. *La Clin. Ophtal.*, May 25, 1906, p. 147.

assumption that it was superior because of its bromide content but there seem to be no facts to substantiate these claims.

The Employment of Somnoform in Ophthalmic Surgery.

Somnoform is a combination of 60 per cent. ethyl chloride, 35 per cent. methyl chloride and 5 per cent. ethyl bromide. The reports thus far to hand would indicate that under proper precautions it is a safe anesthetic. Hess[10] reports its use in 62 operations, including 2 enucleations, the remainder being rhinologic operations. Usually, it induces a narcosis of from two to three minutes, with a subsequent analgesia. Occasionally the narcosis is simply transitory. Hess has had it terminate in less than a minute, necessitating the use of chloroform to complete an enucleation. The dose is usually 5 cc., but this must be increased for large robust persons and for alcoholics. The anesthesia can be prolonged only by repeating the dose, but this robs it of its safety, and freedom from unpleasant after-effects. Our own comment would be that judging from the unsatisfactory manner in which the human economy bears with methyl compounds and its greater tolerance to ethyl compounds, somnoform will in the end be found an undesirable agent.

This conclusion voices the opinion of Peterson[11] who says of this anesthetic in ophthalmic operations that:

"It is not suitable for ophthalmic operations, as the ocular muscles (especially the powerful orbicularis palpebrarum) are among the last to yield to its influence and to become thoroughly relaxed. When this necessary condition is finally attained, the patient has inhaled so much somnoform that he has entered the dangerous stage. Even then the duration of the anesthetic is not more than 90 seconds.

"Vomiting is a frequent sequel, thus rendering it still more unsatisfactory for ophthalmic operations."

The Use of Nitrous Oxide in Ophthalmic Surgery.

Nitrous oxide, discovered in 1776 by Joseph Priestly, was the first gas found to have the property of suspending consciousness; but for many years it was used only in chemistry, before its valuable anesthetic properties were appreciated and put to practical use. Since the publication of Colton's series of 20,000 successful cases,[12] the whole dental world has made almost daily use of this agent. Present day statistics, showing only one fatality in 200,000 administrations, mark it as easily the safest inhalation anesthetic in use. Within the past few years surgeons have also been much attracted by the safety of this anesthetic.

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[10]Hess. *Colorado Medicine*, May, 1905.
[11]Peterson. Wood's *System of Ophthalmic Therapeutics*, p. 381.
[12]Colton. Keen's *System of Surgery*, Vol. 5, 1910.

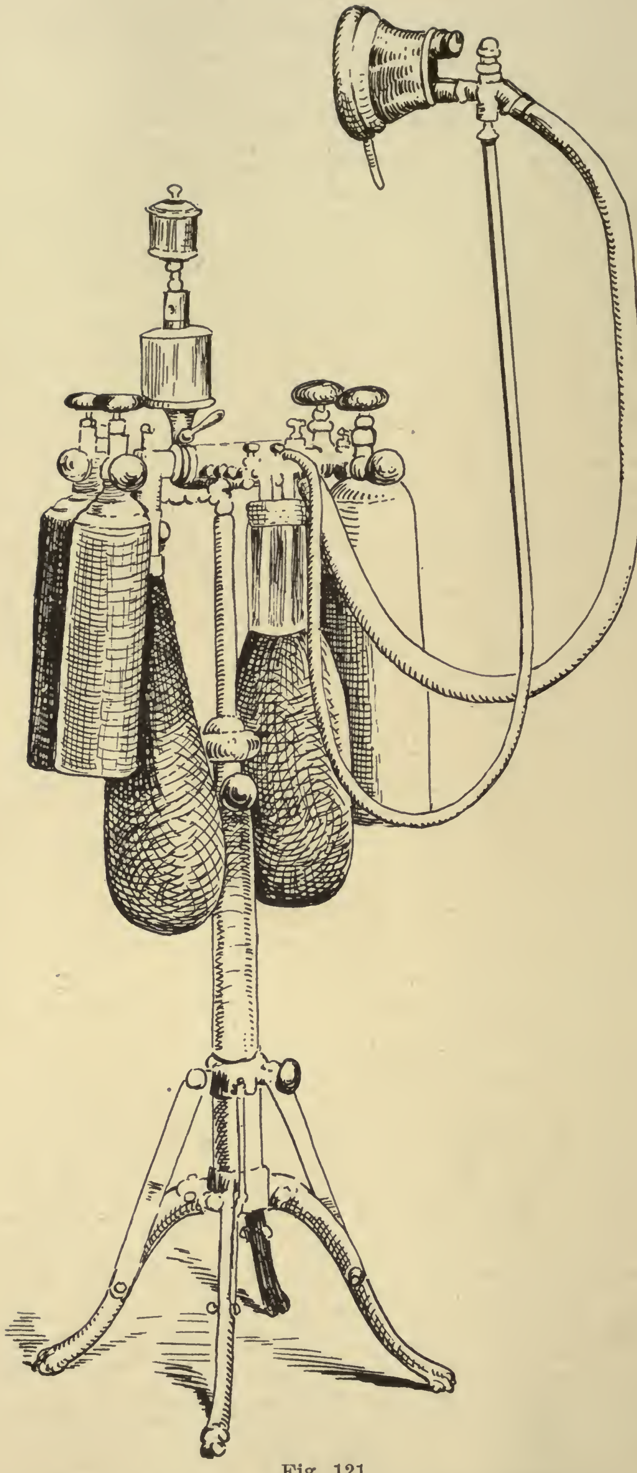

Fig. 121.
The Teter Apparatus for Nitrous Oxide and Oxygen and other Combination Anesthetics, with a small Mask to give the Operator a free Field.

Crile,[13] who with his associates, has been pursuing the research on nitrous oxide (with and without scopolamin-morphin) under the Committee on Anesthesia of the American Medical Association, reports the use of nitrous oxide combined with oxygen in 1,130 cases, of which 1,000 were major operations. Of these 1,000, 139 had nausea (9 of them severe, and of these 9, nausea lasted 2 to 3 days in 4 of them). He

Fig. 122.
Gatch's Apparatus for the Use of Nitrous Oxide by Rebreathing.

is satisfied that in the hands of highly skilled anesthetists the method is the best yet devised. Haggard is practically of the same opinion.

The Teter apparatus (Fig. 121), is primarily a nitrous oxide-oxygen apparatus; it may also be used for ether and cholroform, either alone or with nitrous oxide and oxygen or in sequence. As all vapors

[13]Crile. *Jour. Amer. Med. Assn.*, June 11, 1910.

pass through the vapor-warmer, there is an added factor of efficiency with any agent used.

Gatch[14] has recently devised a nitrous-oxide-oxygen apparatus for anesthesia by rebreathing (Fig. 122), which has been used in Halstead's clinic in 700 cases. It has not only proven its usefulness as an apparatus but has shown that in many cases rebreathing is beneficial in that it causes deeper respiration, pulse slower and rise of blood pressure. The cost is about 1½ cents per minute of anesthesia.

It seems rather strange that so safe an inhalation anesthetic has not found its way more into ophthalmic practice. For transitory anesthesia involving such minor procedures as slitting of a canaliculus, opening a hordeolum or a lachrymal abscess, passing a probe, etc., in nervous or apprehensive patients we have utilized a dental surgeon's assistance in the use of nitrous oxide and have been highly gratified at the results. A brother ophthalmic surgeon has long since employed it in the same way. It is our own feeling that the nitrous oxide-oxygen apparatus may yet become a portion of the ophthalmic surgeon's armamentarium.

The Employment of Scopolamin-Morphin Anesthesia in Ophthalmic Surgery.

The method of inducing general anesthesia by repeated hypodermic injections of scopolamin-hydrobromate and morphin sulphate has been used more or less extensively by certain general surgeons.

Suker[15] has resorted to it in acute glaucoma, cataract extraction, keratectomy and enucleation. He notes absence of excitement either before or after the operation, absence of muscular rigidity, with sufficient consciousness on the part of the patient to obey the surgeon's orders. Insufficient anesthesia was supplemented by cocain or chloroform, of which but very little was needed. Three injections of scopolamin, 1/150 grain, and morphin, 1/6 grain, are made one hour apart, beginning 2¾ hours before the time set for the operation. This method seems safer than either chloroform or ether anesthesia in patients with renal or cardiac lesions, but it is not entirely free from danger, 6 deaths in 3,000 anesthesias having been reported. His feeling is that should the first injection develop any idiosyncrasy to the drugs, the others should not be given but some other plan adopted.

Segelken,[16] from an experience extending over four years, is convinced of the value of this method in cases in which ether or chloroform anesthesia portends especial danger. In the preparation of the patient, Segelken allows them to have fluids freely.

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[14]Gatch. *Jour. Amer. Med. Assn.*, March 5, 1910.

[15]Suker. *Annals of Ophthalm.*, Jany., 1907.

[16]Segelken. Die Skopolamin-Morphiumnarkose in der Augenheilkunde. *Klin. Monatsbl. für Augenhlk.*, July, 1907, p. 75.

Stuelp's[17] experience with this method in 100 cases leads him to state that despite occasional failures, it is to be recommended. In glaucoma iridectomies, complicated cataract and other operations on the eyeball, it makes the operation easier by quieting the patient. No bad effects on the general condition were observed even in general diseases in which inhalation anesthesia was undesirable; and where chloroform was subsequently found necessary, it seemed to act very favorably in the presence of the scopolamin-morphin state. He also used 1/150 scopolamin and 1/6 morphin three times one hour apart. In the cases in which successful narcosis was obtained, consciousness was much obscured but not abolished, so that correct answers were given to energetic questions. After the instillation of cocain in infiltration anesthesia (which was never omitted) no expression of pain occurred during corneal incision, iridectomy, cutting the muscles or inserting sutures. On the other hand the movements of the eyeballs were usually carried out correctly and in a quiet and certain manner.

In Stuelp's 100 cases, good narcosis obtained in 45, in 29 it was incomplete but sufficient to carry out the operation, and in 26 it failed. In some cases it produced slight mental excitement and striking increase of sensibility so that chloroform was required to finish the operation.

Hare[18] insists that this anesthetic is not devoid of danger and its use *alone* for surgical narcosis is not justifiable, while H. C. Wood, Jr.,[19] goes so far as to say that "the method is scientifically irrational, and inasmuch as it has shown a mortality of one per 1,000, and that in 69 per cent. of the cases the anesthesia has been unsatisfactory, we think it must be either a very bold or a very ignorant surgeon who will persist in its use." This is an extreme statement, however. We do not know where Wood gathered his statistics but neither Stuelp nor Segelken, both of whom have used it in over 100 cases, reports any untoward results whatever. We have ourselves used the method in 15 cases, either alone or in combination with ether. The first case was a patient with senile cataract[2] an apprehensive German, aged 68. Instead of anesthesia, a mental excitement was produced, and cocain was needed to complete the extraction. Even then it was a most difficult operation to negotiate. All the subsequent cases were done under scopolamin-morphin narcosis with enough ether to relax the patient (very little being usually needed) and these patients were absolutely quiet, for a 20 to 30 minute operation, without any further ether—an advantage not to be lightly regarded. We have also used the method for iridectomy in glaucoma, for enucleations and for lid operations (ptosis, entropion,

[17] Stuelp. Ueber Skopolamin-Morphium-Narkosen bei 100 augenärtzlichen Operationen, *Klin. Monatsbl. für Augenhlk.*, July, 1909, p. 74.

[18] Hare. Keen's *System of Surgery*, Vol. V, 1910.

[19] Wood. Quoted in the *Annals of Ophthalm.*, Jan., 1906.

etc.), and we feel that in combination with just enough ether to relax the patient the method may prove of much value in ophthalmic surgery.

Preparation of Patients for General Anesthesia in Eye Operations.

Before dismissing the subject of general anesthesia by inhalation, it is necessary to emphasize the wisdom of reckoning with the psychologic phases of the subject. Nervous, apprehensive people need management. Tactful assurance and calming measures (a little preliminary bromide, etc.) are of untold value in securing a successful issue. No patient should be anesthetized in an operating room, with all the preparations for the operations going on about him. For years some of our most prominent surgeons have been in the habit of giving a hypodermic of a quarter of a grain of morphia (and sometimes atropia) one-half hour before the operation, wholly with the idea of calming the patient and "removing the hypertension dependent upon apprehension." Moreover, any patient who is to have inhalation anesthesia should have been submitted previously to thorough examination of the urine and circulation and should have a perfectly empty gastro-intestinal tract. The latter condition is the best preventive of post-operative nausea we know of.

LOCAL ANESTHESIA IN OPHTHALMIC OPERATIONS.

Regional Anesthesia.

Within a very few years foreign ophthalmic surgeons, especially those on the Continent, have been searching for means and methods that will enable them to dispense with general or inhalation anesthesia. The reason for this patient search is that the advantages of local anesthesia are many, despite the fact that general anesthesia is attended by little danger. Hertzler[20] well says that "recent knowledge of the late effects of chloroform cause us to inquire anew if ether also may not have delayed deleterious effects hitherto unsuspected. One death in 16,000, now accepted as the fatality rate for ether, may not express the danger if the remote effects are considered. This is not the place to enter into an inquiry as to the dangers of inhalation anesthesia, but if operators interrogate their knowledge of fatalities after the use of ether in their own practice or that of their friends, faith in the accuracy of the statistics above quoted will be much shaken. When we add to this list those instances in which death occurs, from causes not perfectly clear, after the patient is returned to bed, the doubt is increased. If in addition to this the operator notes the results in a large series of operations under local anesthesia characterized by freedom from

[20]Hertzler. *Amer. Jour. of Surgery*, July, 1910.

such unpleasant experiences, he becomes convinced that ether is not the innocent agent statistics would have us believe."

Evidently moved by similar consideration, Elschnig[21] has made some preliminary anatomic studies, with the idea of employing what he calls *ganglion or regional anesthesia.* The sensitive nerves of the eyeball are the long ciliary from the naso-ciliary nerve and the short ciliary from the ciliary ganglion. The long ciliary nerves arise from the naso-ciliary nerve shortly after the long root to the ciliary ganglion branches off. These sensitive nerves are gathered together at a point and if a few drops of a properly prepared anesthetic solution are introduced in the region of the ciliary ganglion, anesthesia of all the structures of the orbit supplied by these nerves ensues. There is no final evidence at hand in the matter, but the probability is that the ganglion must be bathed in the anesthetic solution.

Elschnig's method is as follows: After cocainization of the conjunctiva in the ordinary way, the external canthus is stretched toward the temple and the needle (¾ of an inch long) introduced through the conjunctiva close to the external orbital margin, slightly below its middle point along the lower border of the external rectus muscle and just escaping the external orbital wall. Finally, the tip of the needle is carried inwards until the end next the barrel of the syringe is barely visible, when one-half of the syringeful is injected. By slight lever motions one guards against engaging the needle in the optic nerve or large blood vessels. The anesthesia, which ought to be established in two minutes, is tested by slight pressure on the globe. If it is not anesthetic the needle is withdrawn about 1 cm. (1/6 of an inch) and again pushed back the same distance but in another direction and the remaining contents of the syringe driven toward the ganglion. Subconjunctival injections of cocain are made about 15 mm. from the limbus at four points in inflammatory cases. Most patients are given 1/6 grain of morphin half an hour previously, which generally has a beneficial psychical effect. In quiet or slightly inflamed eyeballs the pain was practically nil but also in most of the inflamed eyeballs (11 out of 13), complete anesthesia was obtained.

Elschnig[22] and Loewenstein have thus performed 23 enucleations, 7 extenerations, 2 cyclodialyses, and 1 staphyloma excision.

J. E. Brown, Columbus, O., (p. c.) writes that the following are the customs and rules observed in Fuchs' clinic in Vienna:

"General anesthesia is not used for enucleation save in children. A syringe containing 1 cm. of the solution with a needle not less than 5 cm.

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[21]Elschnig. *Enzyklopädie der prakt. Medizin.* Schirmer and Vierordt. Wien, 1905, p. 1195.

[22]Elschnig. Ueber regionäre Anästhesie der Orbita. *Klin. Monatsbl. für Augenhlk.*, June, 1908, p. 592.

long is used. One-fourth of the contents of the syringe is injected over or slightly back of the insertion of the superior, inferior, internal and external rectus. Later one-half a syringeful is injected in the region of the ciliary ganglion, which he reaches just as does Elschnig. This method of enucleation is used in cases of inflammatory glaucoma and iridocyclitis, as well as in non-inflammatory enucleations.

At Siegrist's clinic in Berne, 1 per cent novocain solution is used, the injection being made over the four recti muscles, making a very much deeper one over the external rectus—but I believe he does not so much emphasize the importance of getting the needle near the ciliary ganglion as does Fuchs and others in Vienna."

Brown goes on to say: "Personally I have found this method very satisfactory in a few enucleations and feel that it can be recommended as the method of choice when there are no special contraindications.

H. D. Bruns[23] states that for some years all enucleations in his clinic have been done under "ganglion" anesthesia, except on children and very excitable or timorous people. He employs the following combination:

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4 per cent. cocain solution................10 mm.
1:1,000 adrenalin solution................10 mm.
Normal saline solution....................20 mm.

After the usual cocainization of the conjunctival sac, one-quarter of the above solution is injected along each rectus muscle. After eight minues (two minutes say Fuchs, Elschnig and Siegrist) anesthesia should be complete.

E. A. Robin[24] has used this same method in 34 cases. He prefers to supplement the four injections of Bruns by an additional one about the optic nerve, before severing. He claims entire absence of pain during the operation and absolute safety as against the risks of general anesthesia.

Three enucleations under 4 per cent. cocain by the foregoing method are recorded by Ellis and Langworthy[25] who use a curved needle to carry the final injection back to the optic nerve. All other investigators have found the straight needle quite satisfactory and there seems every reason therefore why it should be used.

Zimmerman[26] prefers for enucleation 5 per cent. alypin with adrenalin 1:1,000 two syringefuls being injected over the recti muscles. Absolutely no complaint was made by any of the patients.

Stutzer,[27] on the other hand, feels that this method should not be

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[23]Bruns. *New Orleans Med. & Surg. Jour.*, Dec., 1909.

[24]Robin. *New Orleans Med. & Surg. Jour.*, Dec., 1907.

[25]Ellis. Enucleation of the Eye, with Cocaine Anæsthesia; Subjective Sensation on Severance of Optic Nerve. *Archives of Ophthalmology*, Jan., 1907, p 39.

[26]Zimmerman. Alypin in der Augenheilkunde. *Klin. Monatsbl. für Augenhlk.*, Sept., 1906, p. 262.

[27]Stutzer. *Zeitschr. für Augenhlk.*, June, 1907.

resorted to for enucleation unless the globe is free from pain and irritation, or the contra-indications to general anesthesia are very strong. But Schleuter[28] in a comparative study of the anesthetics, enthusiastically endorses Zimmerman's claims, although he would use 1 to 2 per cent. solutions of novocain with adrenalin.

Fig. 123.

Points of Introduction of the Needle over the Infratrochlear, Lachrymal and Infraorbital Nerves. (Chevrier and Cantonnet.)

Our own feeling is that if we essayed enucleation by this method (and it appeals strongly) we should resort to novocain (which can be

[28]Schleuter. Vergleichende Untersuchungen über die Wirkung des Kokain und des Novokain. *Klin. Monatsbl., für Augenhlk.*, Sept., 1907, p. 198.

boiled with impunity) rather than to cocain. The latter cannot be boiled without impairing its anesthetic properties and none but boiled solutions should be forced back into a closed cavity which, after the nerve is severed communicates, by way of its sheaths, with the intracranial cavity.

Nerve Trunk Regional Anesthesia.

Utilizing the principle of "nerve block," as Crile calls it, Chevrier[29] and Cantonnet, produce local anesthesia by injections in the region of

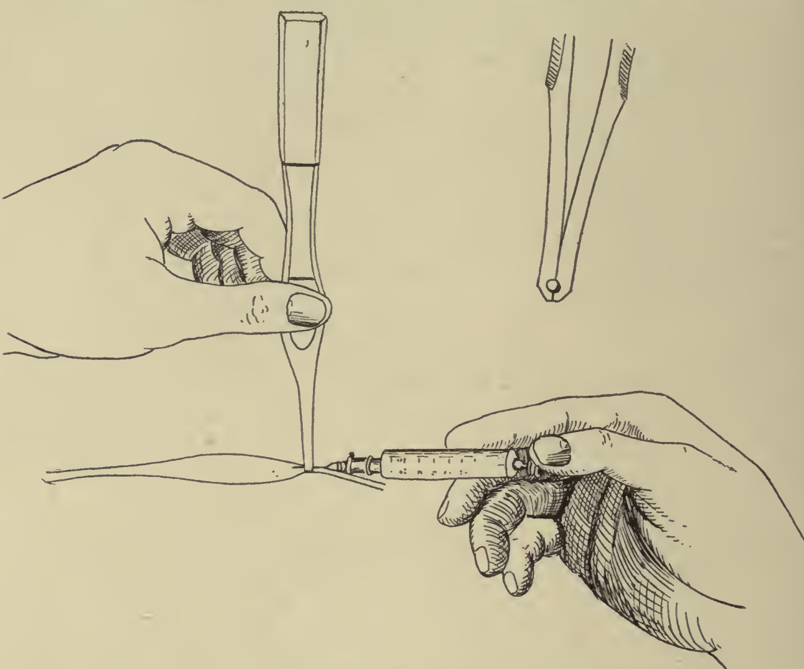

Fig. 124.
Technique of Paraneural Infiltration (Hertzler).

a nerve trunk which they think has a decided advantage over injections directly over or about the site of an operation, 1st, because less anesthetic is required and 2d, because there is less deformity of the part produced by the injection, as shown in Fig. 123.

Oberst,[30] deserves credit for having introduced paraneural infiltration in 1885; while Corning, later, modified the method by injecting the nerve trunk itself with ½ to 1 per cent. cocain solution. Any of the anesthetics may be used (cocain, in ½ solution, stovain 1 per cent., alypin 1 per cent.), but Chevrier and Cantonnet prefer 1 per cent. novo-

[29]Chevrier. *Gaz. des Hôpitaux*, Dec. 9, 1909.
[30]Oberst. Quoted by Hare, Keen's *System of Surgery*, Vol. V, 1910.

cain solution to which is added a little adrenalin (how much not stated). Fifteen minutes is required to penetrate thoroughly the nerve trunk with the anesthetic solution. They point out that the upper lid derives most of its sensitive nerve filaments from the supraorbital—a

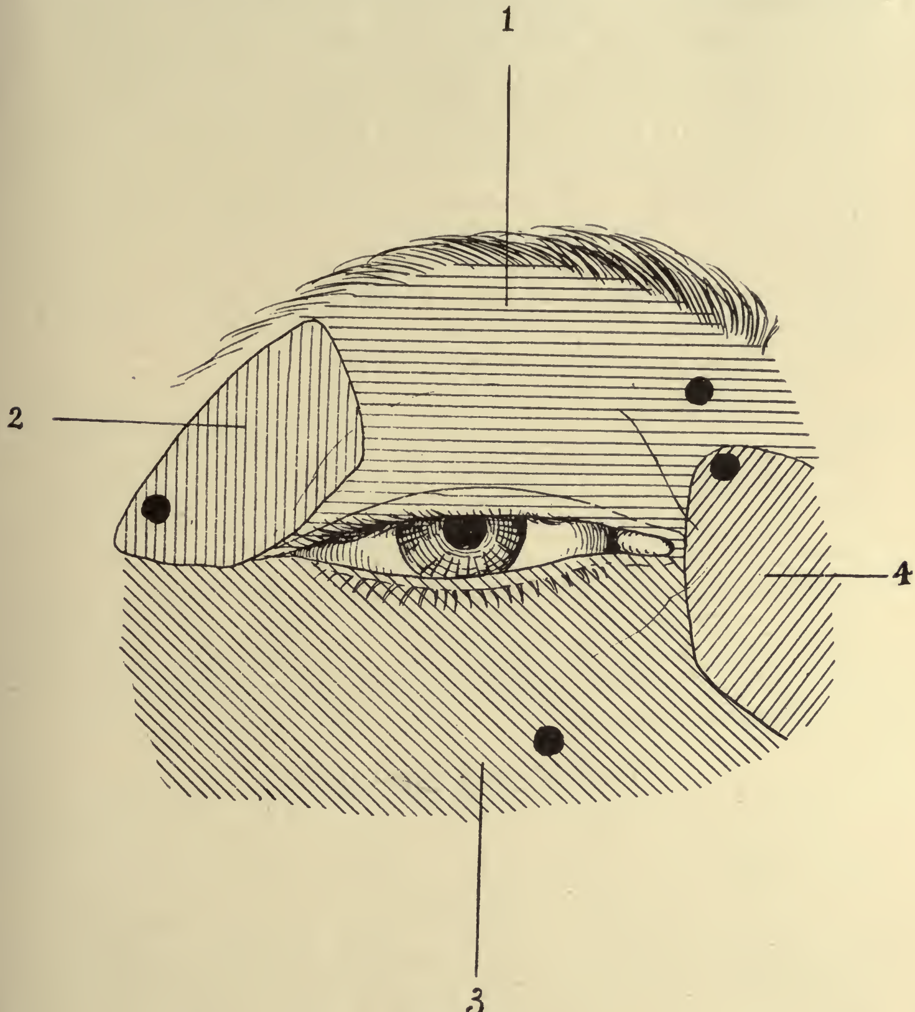

Fig. 125.

Areas of Anesthesia (regional) Produced by the Introduction of Anesthetic Solutions over the Trunk of the (1) Supraorbital Nerve; (2) the Lachrymal Nerve; (3) the Infraorbital Nerve; (4) the Infra- or Subtrochlear Nerve (Cantonnet).

nerve that can be easily located. Sometimes these filaments are given off, however, before the nerve emerges from the orbit. It is necessary, therefore, to approach the nerve in the orbit. The inner fourth of the

upper lid is supplied by the supratrochlear, therefore one injection made along the roof of the orbit above and just external to the pulley for the superior oblique will affect both nerves. The external fourth of the upper lid is supplied by branches of the lachrymal nerves. The lower lid receives its sensitive filaments from the ascending ramifications of the infra-orbital nerve. These anatomic considerations show the necessity of three injections to control the three sources of innervation. For anesthetizing the supratrochlear and supraorbital nerves the needle is inserted above and a little to the inside of the pulley (which is located by the finger) and passed along the roof of the orbit upward and outward 1 to 1½ cm., pushing on the piston as the syringe is inserted in order to have the fluid in advance of the needle. The injection for the lachrymal nerve (not sac) is made about two centimeters (⅓ of an inch) from the external canthus, carrying the needle after entrance upwards and inwards three or four cm., when the anesthetic is deposited between the periosteum and the lachrymal gland.

The injection for the *infraorbital,* according to the authors, is made at the level of the infraorbital foramen with the needle of the syringe in the axis of the canal (see Fig. 125), and anesthesia of the lachrymal sac is obtained by subtrochlear injection. The pulley having been located, the needle is inserted below and a little to the inner side of it until the internal wall of the orbit is felt.

They have applied this method in 21 cases, embracing trachoma operations, lachrymal sac extirpations, Panas' operation for entropion, chalazia, tarsorrhaphy and cauterization. The results were uniformly excellent. The method really stands about half way between regional and infiltration anesthesia.

INFILTRATION ANESTHESIA.

By infiltration anesthesia we mean the introduction of any anesthetic solution into the skin itself *(intracutaneous anesthesia)*; or directly under it *(subcutaneous anesthesia)*.

Local anesthesia thus induced has been tried by many surgeons and abandoned, mainly because they did not thoroughly learn the technique of infiltration anesthesia. See Fig. 127. Being accustomed to the total anesthesia of ether or chloroform, they chafe under the restrictions imposed by the infiltration method, which calls for more accurate conception of the finer steps of the operation and for better knowledge of the anatomy of the parts. The prime requisite is a well made glass syringe and clean sharp needle, both of which should be boiled before using.

In 1889 Schleich[31] discovered that by adding normal saline solution to the ordinary cocain solution much less cocain was required to desensitize a part. Indeed a few investigators went so far as to use nor-

mal saline only. In some instances this suffices but a small percentage of cocain insures the effect. All infiltration solutions should at least be made isotonic with the tissues by carrying sodium chloride in the proportion of 0.92 per cent. Latterly it has become the custom to add 1:1,000 adrenalin also. Hare *(loco. cit.)* points out that the reason adrenalin so greatly augments and prolongs the paralyzing effect of the cocain on the nerves and their organs, is that, like freezing, or a stasis bandage or an Esmarch bandage, it temporarily arrests the circulation and so "incarcerates the cocain," to adopt Corning's expression. Indeed, this very effect may be carried too far and result in localized gangrene as shown by Foisy,[32] Luke,[33] and Stragardt.[34] The last named author used suprarenalin and cocain; Foisy and Luke stovaine and adrenalin.

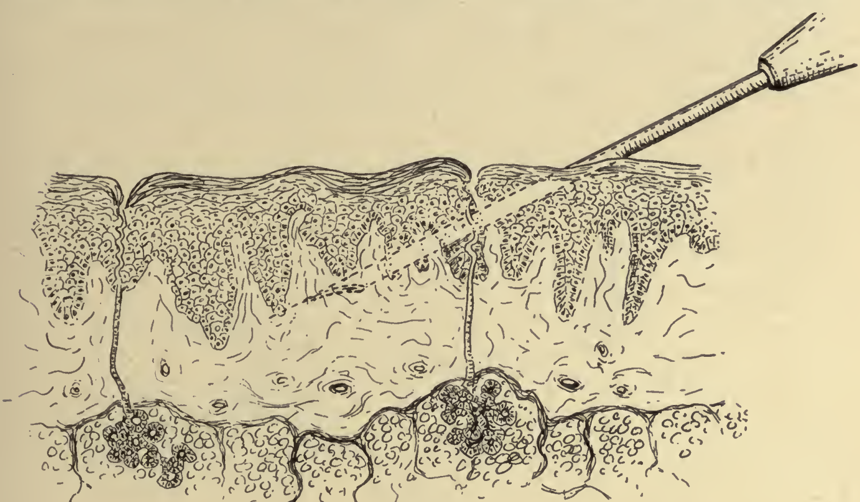

Fig. 126.

Showing just how Far the Hypodermic Needle should be Introduced for the Production of Infiltration Anesthesia (Hertzler).

Recently the subject has been thoroughly worked out on the lower animals, for which see Le Brocq's report farther on.

It would seem to be safer not to resort to any mixture of a local anesthetic with preparations of the suprarenal gland for injection into the tissues, unless they are used in very small amount and dilute solutions.

Various Methods of Securing Infiltration Anesthesia with Cocaine.

To Würdemann[35] is ascribed the credit of introducing infiltration

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[31]Schleich. *Ueber schmerzlöse Operationen,* Berlin, 1889.
[32]Foisy. *Tribune Médicale,* Sept. 18, 1904.
[33]Luke. *Scottish Med. & Surg. Journal,* Aug., 1905.
[34]Stargardt. Nekrosen nach Suprarenin-Injektionen. *Klin. Monatsbl. für Augenhlk.,* Feb.-March, 1909, p. 213.
[35]Würdemann. *Jour. Amer. Med. Assn.,* Oct. 29, 1904, and Nov. 16, 1905.

anesthesia into ophthalmic practice in this country,[36] Schleich's solution proving in his hands most satisfactory.

For operations on trachoma, J. Guttman[37] first uses cocain or holocain in the conjunctival sac, following this up with injections *under the conjunctiva* of the upper lid and well back into the fornix, of sodium chloride 0.2, cocain 0.5, distilled water 100. Not more than four to five drops of the solution are necessary. He has thus desensitized the tissues in 52 consecutive excisions or "rollings" for trachoma, the age of the patients ranging from 6 to 52 years. 36 had no pain, 13 whimpered, and 8 were quite painful. As advantages over general anesthesia he claims: 1, no hospital accommodations are necessary; 2d, no assistant is needed.

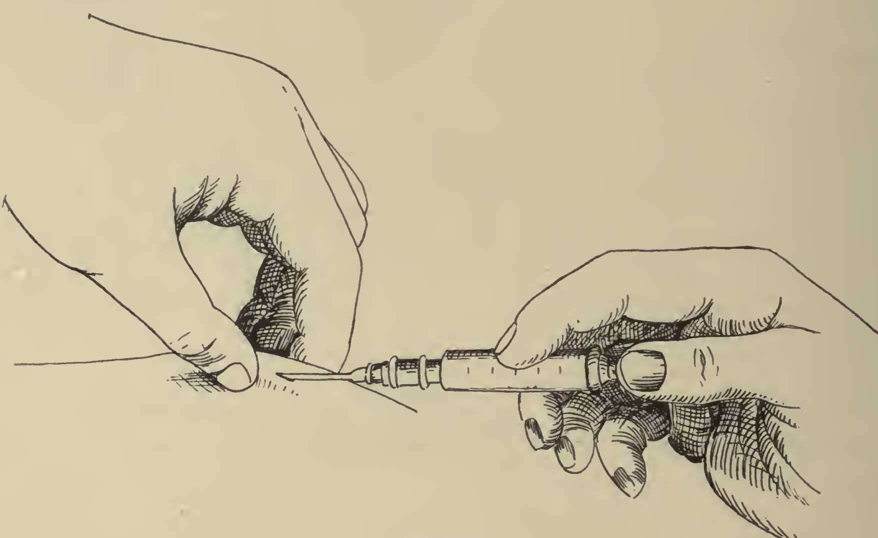

Fig. 127.

Proper Technique for the Production of Infiltration Anesthesia (Hertzler).

H. D. Bruns[38] and Robin employ for lachrymal sac extirpations the same solution they use for "ganglion" anesthesia, namely 4 per cent. cocain solution, 10 minims, 1,1,000 adrenalin solution 10 minims, normal saline solution 20 minims. They would not think of resorting to general anesthesia for this operation.

After ten years' experience with the same solution Stutzer[39] is of

[36]See also, in this connection, Cholewa (Casey Wood) on Local Anesthesia Produced by Intracutaneous Injections. *Jour. Am. Med. Assocn.*, May 26, 1894, p. 778.

[37]Guttman. Report of a new Method for the Application of Local Anæsthesia in Operations on the Eyeball and Eyelids, Especially in Trachoma. *Arch. of Opthal.*, May, 1904, p. 302.

[38]Bruns. *Trans. Amer. Ophthal. Soc.*, Vol. XI, part 1, 1906.

[39]Stutzer. *Zeitsch. für Augenhlk.*, June, 1907.

practically identical opinion with that of Bruns and Robin. In all operations on the lid and lachrymal sac this is the method of selection, in his opinion.

Substitutes for Cocaine in Infiltration Anesthesia.

Holocain, because of its toxicity when used subcutaneously, is not to be thought of in this connection but alypin, novocain, acoin and stovaine have all been rather extensively employed.

After systematic use of *alypin* (five per cent. solution), Zimmermann[40] feels that it is undoubtedly the best substitute for cocain. Its vasodilator properties, so much dreaded by several authors, may easily be controlled by admixture with adrenalin. Moreover it is cheaper than cocain and can be boiled with impunity. These claims of Zimmermann are supported by Sydney Stephenson.[41] Truc[42] on the other hand has combined the effect of both alypin and cocain of the same strength for interstitial anesthesia, but could find no appreciable difference save that the tendency to toxemia is less with alypin.

As to *Novocain,* Schleuter[43] places it first for this purpose in 1 per cent. solution. One fact he emphasizes is that too concentrated solutions (especially in combination with adrenalin) may induce local gangrene, while too dilute solutions, on account of the greater quantity of infiltration fluid, may distend the parts and disturb one's ideas of the anatomic relations. Wickerkiewicz[44] also favors novocain for interstitial anesthesia but believes its anesthetic effect is inferior to that of cocain.

Stovaine in 2 per cent. solution is the favorite drug with Santos-Fernandez[45] for lid operations, as he secures an especially wide area of anesthesia with it. 50 ccs. of the solution are used along lines of the incisions. Krauss,[46] (Marburg) and Marin[47] both combine stovain and acoin as follows: Acoin 0.025, cocain 0.05, normal saline solution 5.00; about 2 ccs. are used about the field of operation at each puncture point.

A recent report on the local anesthetics recommended as substitutes for cocain in infiltration anesthesia has been submitted by Le

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[40]Zimmermann. Alypin in der Augenheilkunde. *Klin. Monatsbl. für Augenhlk.*, Sept., 1906, p. 262.

[41]Stephenson. *The Ophthalmoscope*, Nov., 1905.

[42]Truc. *Révue Générale d'Ophtal.*, March 31, 1906.

[43]Schleuter. *Klin. Monatsbl. für Augenhlk.*, Aug.-Sept., 1907.

[44]Wicherkiewicz. Einige Betrachtungen über Novokain anästhesie in der Augenheilkunde. *Wochensch. f. Therap. u. Hyg. des Auges.*, Feb. 14, 1907, p. 153.

[45]Santos Fernandez. La stovaine pour l'opération de l'entropion de la paupiére inférieure. Révue Gén. d'Ophtal., March, 1906, p. 99.

[46]Krauss. *Muench. Medicin. Wochenschr.*, 1902, No. 34.

[47]Marin. Anestesia local en las operaciones de los parpados, producida por la asociacion de la estovaina, adrenalina y acoina. *Arch. de Oftal. Hispano-Amer.*, Sept., 1907, p. 487.

Brocq[48] who has been conducting an experimental investigation on animals in the Pharmacologic Laboratory at Cambridge, England, under the auspices of the Therapeutic Committee of the British Medical Association. He has investigated stovain, novocain, tropacocain, betaeucain, alypin, betaeucain lactate, nirvanin, holocain hydrochlorid, acoin, orthoform (new) and anesthesin, and has presented a report that commands the attention of all ophthalmic surgeons. It has been found that all of them are general protoplasmic poisons having a special predilection for nervous structures; if used in sufficiently strong solutions they depress and ultimately destroy every form of living tissue.

The points to which special attention has been paid are those laid down by Braun as essential in comparing local anesthetic action. They are: (1) a lower degree to toxicity than cocain in proportion to its local anesthetic power. (2) Sufficient solubility in water. The solutions should be stable, that is, they should keep without deterioration and be capable of sterilization by boiling. (3) Absence of any sign of irritation. There should be no injury to the tissues, the local anesthetic should be easily absorbed without causing any after-effects, such as hyperemia, inflammation, infiltration, or necrosis. (4) Compatibility with adrenalin. (5) Rapid penetration of the mucous membrane, and suitability for medullary anesthesia. The only exception made to these postulates is that dealing with absorption; it is not obvious that easy absorption is desirable; if absorbed slowly, the drug produces more prolonged action. For this reason adrenalin is injected with these substances, producing local vaso-constriction and thus giving the anesthetic a longer time for action. If a drug can be obtained which fulfills the above conditions, it may safely be said that it will supersede cocain.

A drug which is not soluble in water to the extent of two per cent. has been regarded as unworthy of competing with cocain. This throws out acoin, holocain, anesthesin, orthoform (new) and betaeucain.

Cocain, stovain, novocain, tropacocain, betaeucain, lactate, alypin, and nirvanin are freely soluble in water, their solutions are stable, and as a two per cent. solution they will keep for a short time without deterioration. Cocain cannot be boiled, as decomposition occurs, and the drug loses its activity and is gradually destroyed. Stovain, novocain, betaeucain lactate, tropacocain, alypin and nirvanin can be sterilized at 115 degrees C., if necessary, as they withstand this temperature without change and are as active after as before sterilization.

Regarding local anesthetic properties, it was found that stovain has a more powerful anesthetic action; weight for weight, than any of the other local anesthetics. Alypin, betaeucain lactate, novocain and

[48]Le Brocq. *British Med. Jour.*, March 27, 1909.

tropacocain have anesthetic properties about equal to cocain. Nirvanin as a local anesthetic is inferior to cocain.

"Concerning *toxicity,* as determined by the smallest dose which will kill frogs, mice and rabbits, it was found that alypin has anesthetic powers equal to cocain, but a higher toxicity, and so does not comply with the conditions enuciated by Braun. Nirvanin has not the anesthetic power of cocain, and it is only slightly less toxic. As, however, we have found four drugs equal to or stronger than cocain in anesthetic power, and considerably less toxic than nirvanin, no further experiments with this drug were deemed necessary. From this it will be seen that only four drugs, namely, stovain, novocain, tropacocain and betaeucain lactate, have complied with the first two conditions. With these four drugs further experiments were performed to discover how they fulfill the other conditions laid down for the perfect infiltration anesthetic."

Next, the irritant action on the tissues was investigated, and it was found that the irritant action of stovain, betaeucain lactate and tropacocain is far greater than that of cocain; novocain is the only drug which is superior to cocain in this respect.

All the local anesthetics are compatible with adrenalin if the solutions are fresh and kept only for a short time. After a day or two the adrenalin decomposes unless it is kept in a stoppered opaque bottle.

The main conclusion reached is *"that of the drugs which have been investigated, novocain is most satisfactory for general use. Its anesthetic action is equal to that of cocain, and its toxicity and general destructive power on the tissues are very much less."* If this laboratory result, which apparently has been very carefully and very definitely arrived at, is supported by practical everyday work, it seems probable that in novocain we have been presented with very nearly the ideal anesthetic for infiltration anesthesia.

Quinine and urea bimuriate is among the latest aspirants for local anesthetic honors. It is soluble in its own weight of water and is non-irritating hypodermically.

E. J. Brown[49] experimented with 3 per cent. solution for the removal of tonsils and secured perfect anesthesia for a number of hours. Severe sloughing after deep infiltration was observed by J. A. Wyeth[50] and he is now experimenting with a different formula. McCampbell's[51] experiments indicate its power to induce temporary paralysis in animals. Hertzler,[52] Brewster and Rogers confirm Thibaut's[53]

[49]Brown. *Jour. Amer. Med. Assn.*, Aug. 8, 1908.
[50]Wyeth. *New York Polyclinic Jour.*, Jan., 1908.
[51]McCampbell. *Jour. Amer. Med. Assn.*, March 16, 1907.
[52]Hertzler. *Jour. Amer. Med. Assn.*, Oct. 23, 1909.
[53]Thibaut. *Jour. Amer. Med. Assn.*, Sept., 1907.

claims, but they feel that 1 per cent. solutions delay healing somewhat and suggest 1/4 to 1/2 per cent. solutions for hypodermic use. They all agree that 10 per cent. solutions may be applied locally to mucous membranes, and prefer sterile water as a vehicle because of the more lasting anesthesia.

Thus it will be seen that as with general anesthesia so with infiltration anesthesia, surgeons make of certain drugs their favorites, and, learning their fullest field of application as well as their limitations, hold fast to that which has proven itself good in their hands.

Intracutaneous Anesthesia.

A remedy that was in great favor with the older surgeons but that has practically fallen into disuse, is the *local application of carbolic acid solution* (2 to 10 per cent.) over the cutaneous areas to be attacked. That it does the work and does it well cannot be denied. Its ease of use and accuracy of application commend it as a method that might well be revived. To create a starting point for the hypodermic needle in subcutaneous anesthesia it is ideal.

FREEZING MIXTURES.

From time to time meagre reports have come to hand concerning various freezing mixtures that may be used in ophthalmic surgery, such as the *rhigoline spray* introduced by Richardson. This method has been variously modified, but because of the vapor that liquefies and may easily run into the eye it is not practical for ophthalmic operations. Freund (quoted by Elschnig) has employed liquid air for local anesthesia and a few surgeons have tried the "carbon dioxid snow" (see Fig. 128) in the form of ice pencils, so-called, but the office-apparatus for the production of the pencils is rather costly and may make it prohibitive. However, it has been found of value in the desensitizing and removal of cutaneous growths and may become useful in the treatment of rodent ulcer.

MUCOUS ANESTHESIA.

This is the phase of local anesthesia that is of most interest to all ophthalmic surgeons. And the same caprice that manifests itself in the choice of a general anesthetic is even more in evidence in the choice of a local anesthetic. Ever since Koller's[54] epoch-making discovery in 1884 of the local anesthetic power of cocain upon the eye, it has retained its place as the anesthetic of election with the majority of

[54]Koller. Vorlaüfige Mitthelungen ueber lokale Anesthesirung am Auge. *Bericht der Ophthal. Gesell,* 1884.

ophthalmic surgeons the world over, in spite of its drawbacks and the host of later discovered anesthetics.

As cocain is the type of all the other anesthetics we shall treat of it first.

Cocain.

The anesthetic action of cocain upon the tissues of all warm-blooded animals is due to its paralysing action on the terminals of the sensitive nerves. The eye, because of its large sensory nerve supply, represents a most perfect tissue for the action of cocain. In conse-

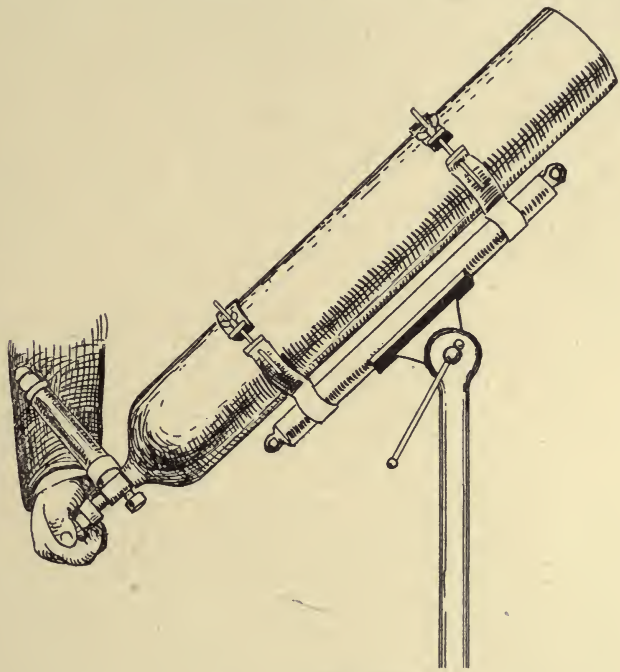

Fig. 128.

The Grossman Company's Office Apparatus for the Preparation of Pencils of "Carbon Dioxid Snow."

quence of this action anesthesia usually appears ½ to 1 minute after the instillation of a 2 to 4 per cent. solution.

If 2 or 3 instillations are employed, the cocain (by its influence on the interepithelial cement substance) diffuses through the cornea and in about ten minutes produces moderate mydriasis by stimulating the fibres of the sympathetic nerve in the iris. About this same time widening of the interpalpebral fissure is noted, probably due to the stimulating effect of the cocain upon the fibres of Müller's muscle. In many individuals a more or less transitory reduction in the amplitude of accommodation accompanies the mydriasis above noted. Within

two minutes the eye is quiet enough to permit the removal of foreign bodies from the cornea or conjunctiva, or to allow inspection of the same as well as the fornix of the conjunctiva, and in sensitive persons to make any kind of application to the palpebral conjunctiva or cornea. Surgical anesthesia, however, is usually not established in less than five or more minutes after the first instillation.

The usual *method of application* in this country is to use two drops of a 2 to 4 per cent. solution in the conjunctival sac every three minutes for four or five instillations (9 to 12 minutes), by which time the deep-lying intraocular tissues are generally pretty well desensitized. The eyes should be kept closed during all this time to prevent as much as possible the dessication of the corneal epithelium that often constitutes one of the contra-indications to the use of cocain.

The chief *advantages* of cocain are, 1, ease of obtaining it anywhere; 2, its cheapness; 3, prompt, trustworthy anesthesia, because of its diffusibility through the cornea; 4, hemostatic action on all the blood vessels of the eye; 5, it is perhaps less irritant when instilled (warm) than any of the other anesthetics.

The *disadvantages* of cocain are, 1, its deleterious action on the corneal epithelium, which is said by some to favor the post-operative infection and by others to delay the healing of the wound. (At the same time it must be remembered that all local anesthetics are more or less protoplasmic poisons and if used in sufficiently strong solutions are almost sure to affect the corneal epithelium unfavorably.) 2. Its accompanying mydriasis. 3. The occasional partial cycloplegia; neither of the foregoing objections, however, seem to us to weigh very heavily when surgical anesthesia is sought. 4. Reduction of the intraocular tension. This may sometimes prove an annoying complication by disturbing the operator's tactile sense with the instruments. 5. Its solutions cannot be boiled. This is thought by many a grave objection, particularly as to its use in intraocular operations, but if solutions freshly prepared from sterile water are used, little danger need be apprehended. For some years we have had our cocain solutions prepared with sterilized saturated boric solution, which is filtered after the solution is made. Such solutions have remained free from penicillium as long as three months at a time and for all office operations are safe. For intraocular operations freshly prepared solutions, as just specified, are safest. Cocain solutions might well be made isotonic with the ocular tissues as urged by Cantonnet,[55] who employs 14 parts of sodium chloride per 1,000 parts of water as the basis of all solutions.

[55]Cantonnet. Formules de collyres isotoniques aux larmes. *Arch. d'Ophtal.*, Oct., 1908, p. 617.

To avoid the dessication of the cornea often produced by cocain and to render the solution less irritating Scrini[56] has for some years past resorted to oily solutions of the pure alkaloids and claims longer anesthesia with the same strength solution.

He prefers olive oil first washed for several days with half its volume of 95 per cent. alcohol to free it from fatty matter. It is next decanted and filtered, and then sterilized over a sand bath for about 10 minutes at 120°. Darier and v. Pflugk endorse every claim Scrini has made for oily solutions.

We have personally only tried the oily solutions recently. Unfortunately they almost immediately cause a thin oily film over the cornea that may well obscure the fine details in any operation.

SUBSTITUTES FOR COCAIN.

Holocain.

This, the first substitute offered for cocain, was introduced into ophthalmic work in 1896. It is a synthetic derivation of phenetidin. The alkaloid is feebly soluble in water (1 to 160) and is of neutral reaction.

The hydrochloride, which can be boiled without affecting its anesthetic qualities, is soluble to almost 2 per cent. in water, and has quite displaced the alkaloid for surgical purposes. Anesthesia of the eye supervenes in one to three minutes after one drop of a 1 per cent. solution, and lasts ten minutes.

J. Hirschberg[57] in 1899 had performed several hundred major and minor operations under holocain without accident and preferred it for all operations save enucleations. In the same year the elder Knapp[58] announced that he was using holocain almost entirely in all operations on the anterior part of the eye, instead of cocain, and recently we have been favored with a personal communication from Arnold Knapp to the effect that they "are still using 1 per cent. holocain with satisfaction on account of its antisepsis, its slight effect on the corneal epithelium, and the absence of effect on the pupil."

In 1898, R. L. Randolph[59] conducted elaborate laboratory experiments with various bacilli and showed that 1 per cent. holocain solutions not only have an inhibitory effect upon these organisms but kill them after a certain length of time. Since then this drug has grown steadily in ophthalmic favor, having been endorsed by many foreign and home investigators, who have used it in a large series of cases, and are entirely satisfied with it as an anesthetic and as an

[56] Scrini. *De l'emploi des Alcaloides en solution huileuse*, Paris, 1906.
[57] Hirschberg. *Centralbl. f. prakt. Augenhlk.*, June, 1899.
[58] Knapp. *Archives of Ophthalm.*, May, 1899, p. 315.
[59] Randolph. *Jour. Amer. Med. Assn.*, May 14, 1898.

agent superior to cocain. There are, however, a few dissenting voices; among them Haskett Derby[60] and Hotz,[61] who insist that it is much more painful and more irritating than cocain and less benumbing to the deeper structures.

Eucain and Beta-Eucain.

A rival to both cocain and holocain was brought out by Schering in 1896 and called Eucain-B.

It was clinically reported on by Silex,[62] who found it: 1. 4 to 5 times less toxic than cocain. 2. Unchanged by boiling. 3. Solutions kept perfectly four months. 4. Possessing a feeble bactericidal power. 5. Without effect on the pupil and accommodation. 6. Cheaper than cocain.

Beta-eucain lactate has recently been brought forward as an improvement on eucain-B, and has been tried by two or three investigators with indifferent results thus far.

Tropacocain.

Tropacocain was discovered by Giesel in 1891 and was soon after prepared synthetically. According to various investigators its virtues (in three per cent. solution) consist in its slight toxicity, its more rapid and enduring anesthesia, its slight influence on the pupil and accommodation, the permanence of its solutions and its improved qualities when made isotonic by the addition of sodium chloride. We have never tried it ourselves.

Stovain.

This substance belongs chemically to the benzol group. It crystallizes readily, is extremely soluble in water, and its aqueous solutions show no alteration after prolonged boiling. Four per cent. solutions produce considerable smarting (we should say a good deal more than cocain from its use in our own eyes) and anesthesia occurs in from two to five minutes. Stephenson *(loco cit.)* thinks the discomfort is no greater than after cocain, and finds it without effect on the blood vessels. In his hands the duration of the anesthesia was from 10 to 30 minutes. He observed slight dilation of the pupil but no effect on the accommodation. It is used chiefly in 2 to 4 per cent. solutions, de Lapersonne having resorted to the latter strength for 18 cataract extractions and 4 iridectomies. Slight disturbance of the corneal epithelium was noted by him several times.

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[60]Derby. Holocain in Ophthalmic Surgery; Its Superiority over Cocaine; Its Therapeutic Value. *Archives of Ophthalm.*, Jan., 1899, p. 45.
[61]Hotz. *Amer. Jour. Med. Sciences*, Feb., 1898.
[62]Silex. *Deutsch. Med. Wochensch*, No. 6, 1897,

Alypin.

We are indebted to Impens[63] for the introduction of alypin. It is a glycerin derivative, extremely soluble in water, not precipitated by the alkaline fluids of the body and can be boiled indefinitely. It is less toxic than cocain, and is employed in 2 per cent. solution conjunctivally. Sydney Stephenson *(loco cit.)* believes there is less smarting with alypin than with cocain, but Jacques, using alypin in one eye and cocain in the other, says that patients complained more of the alypin.

Novocain.

Braun[64] offers this agent as another addition to our list of local anesthetics. It occurs in needle-like crystals, soluble in their weight of water. The hydrochlorate is the best for ophthalmic use. Verderame's[65] tests on the corneas of rabbits show that 2 to 10 per cent. solutions produced irregular erosions of the epithelium and in the stronger solutions extensive loss of corneal substance. The evidence seemed to be that strength for strength the deleterious action of novocain is greater than that of cocain, while the anesthesia is less intense.

In our own hands novocain has proven very unsatisfactory for anesthesia of the mucous surfaces.

Acoin.

Acoin was introduced in 1899 by Trolldenier and in the same year was investigated by R. L. Randolph.[66] With 1/3 to 1 per cent. solutions he secured satisfactory anesthesia in uninflamed eyes in about the same time as with cocain. He also noted no influence on the pupil, the accommodation or the cornea. Darier[67] has been its chief advocate, but more for subconjunctival than for conjunctival use.

Led by his favorable experience in a painful erosion of the cornea, v. Pflugk[68] has employed 1 per cent. solutions of acoin in olive oil in over 100 cases, and cannot speak too highly of its properties. At times patients did not know it has been instilled. The effect of two to three instillations varies in duration for one-half hour to 5 to 6 hours. Along with Darier, Scrini and others, he lays great stress on the way the olive oil is treated before being used as the vehicle. "It should first be washed for several days with half its volume of

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[63]Impens. *Deutsch Medicin. Wochenschr.*, No. 29, 1905.

[64]Braun. *Die Lokalanesthesis, ihre wissenschaftliche Grundlage und prakt. Anwendung*, Leipsig, 1905.

[65]Verderame. *Zeitschr. für Augenhlk.*, Sept., 1907.

[66]Randolph. A Communication Upon Acoin—A New Local Anæsthetic. *Ophthalmic Record*, July, 1899, p. 401.

[67]Darier. *La Clinique Ophtal.*, Oct., 1899.

[68]von Pflugk. *Wiener Medicin. Presse*, March 17, 1907.

95 per cent alcohol, to free it from fatty matter, then decanted and filtered and lastly sterilized over a sand bath for ten minutes."

Some years ago we experimented with 1 per cent. solutions of acoin (base) and were very favorably impressed with it.

Yohimbin.

Chief among the less well known substitutes is *yohimbin,* introduced by Magnani of Turin. The alkaloid is derived from the yohimbehe tree of West Africa. It is soluble in water only to 2 per cent., but freely so in alcohol. The hydrochlorate (now procurable and more soluble in water) will doubtless prove more popular than the base. Unfortunately its solutions deteriorate very rapidly. Claiborne[69] and Coburn observed that the congestion produced by yohimbin must label it inferior to cocain as an anesthetic in all operations on the eye.

Frynin.

This is an alcoholic extract obtained from the parotid glands of toads, which Popow[70] has employed for optical iridectomies and discission of cataract. One per cent. solutions set up considerable irritation and hyperemia and some disturbance of the corneal epithelium.

Aneson.

Has been employed by Sternberg in 2 per cent. solutions for various ophthalmic operations.

Oil of Guaiac.—As a 6 per cent. solution in olive oil, it is reported by Bellencoutre[71] as producing sufficient anesthesia for all operations save those of opening the anterior chamber.

Quinin and Urea Bimuriate.

Lastly we refer to this preparation recently brought forward as an ideal agent for subcutaneous anesthesia. On mucous surfaces, however, it does not seem to work so well. Less than 5 per cent. solutions do not produce trustworthy mucous anesthesia and 5 to 10 per cent. solutions are extremely irritant (proved by instillations in our own eyes) and induce a hyperemia of 15 minutes to ½ hour's duration. The anesthesia of the anterior structures seems of about 1 hour's duration, but our observations only embrace a few cases.

Thus it will be seen that the *ideal* local anesthetic for mucous surfaces, a non-toxic, non-irritating substance that can be boiled, whose only action would be to paralyze the terminals of the sensory nerves without influence on the tension, the corneal epithelium, the

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[69]Claiborne. *Medical News*, July 9, 1904.
[70]Popow. *Ophthalmic Review*, Jan., 1906.
[71]Bellencoutre. *Journal de Médicine de Paris*, Dec. 22, 1895.

pupil and the accommodation—has not yet been found. No one anesthetic meets all of these requirements. Holocain seems to approach the ideal most nearly and yet cocain in 2 per cent. solution presents so few disadvantages and so many excellent qualities that it is to-

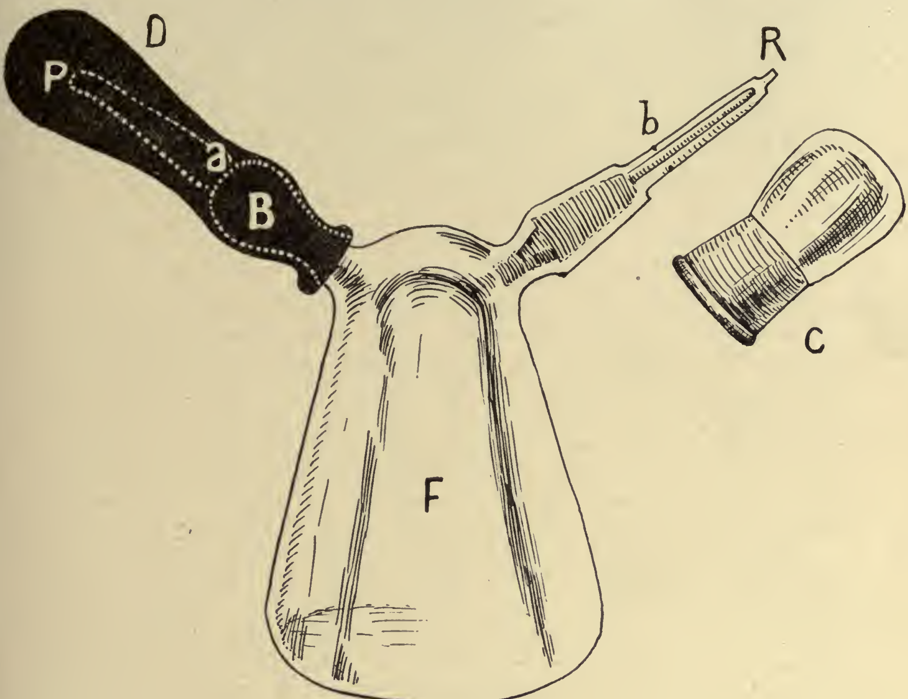

Fig. 129.

Modification of the "Undine," both for the Sterilization and Keeping Sterile of Anesthetic Solutions.

day, as we remarked before, probably the local anesthetic of election among the majority of ophthalmic surgeons the world over.

A receptacle for sterile, local, anesthetizing solutions is pictured (Fig. 129) in the text. Its purpose is evident at a glance and we believe it to be one of the best containers in the market.

CHAPTER VI.

SOME REMEDIES, APPLIANCES AND PROCEDURES EMPLOYED IN MINOR OPHTHALMIC SURGERY.

By CASEY A. WOOD, M. D., D. C. L., Chicago.

Collyria—Eye Lotions—Eye Washes—Eye Waters—Medicine Droppers—Ampullæ—Irrigators—Undines—Irrigating Fluids— Solutions for Douching the Conjunctival Sac—Eye-cups—Sprays—Eye Shades—Goggles—Enforced Rest of the Ocular Apparatus—Protective Bandages and Dressings—Collodion—Local Anesthetics—Applications of Heat and Cold—Massage of the Lids and Eyeball—Brushing—Swabbing—Grattage—Brossage—Lymphagogues—Subconjunctival Injections—Paraffin and Gelatine Injections—Intravenous Injections—Intraocular Medication—Leeches—Artificial and Natural Leeches—Local Bleeding—Wet Cupping—Water Bags and Similar Appliances—Compresses—Cataphoresis—Counter-irritants—Rubefacients —Cautery—Chemical Cauterants—Caustics—Escharotics—Blisters—Vesicants—Vaso-constrictors—Sweat Baths—Hydrotherapy—Bier's Congestive Method—Hyperemia Treatment—Phlebotomy—Venesection—General Blood-letting—Serum Diagnosis and Serotherpathy in Ocular Operations—Artificial Eyes and Similar Devices—Protheses Oculares—Operations for the Cure of Ametropia—Tattooing.

There are quite a few remedies that do not, strictly speaking, belong to a work on Ophthalmic Operations but inasmuch as they are closely allied to these procedures and form rather an important part of minor surgical technique, I think that it is not improper to speak of them in this *System* under the above caption. Most of them have already been considered in various chapters of the volume entitled *A System of Ophthalmic Therapeutics,* and I would respectfully refer the reader to that work for a more elaborate treatment of subjects that really form a sort of connecting link between operative and non-operative ocular therapy.

As there is no natural or definite line of demarcation between these two subjects the list of such remedies might be extended almost indefinitely. The agents whose description comprise this chapter have, consequently, been chosen quite empirically but it is hoped that no remedy of (minor) operative importance has been ignored.

Collyria, Eye Lotions, Eye Washes, Eye Waters.

In mediæval times this first name indicated a suppository or medicated bougie. Later, a powder or solid body applied to the eye, as well as gaseous remedies, was also called a collyrium, but nowadays the term is almost entirely applied to any medical lotion, generally antiseptic or astringent, for use as an eye water. As such the collyrium is the commonest form of external application to the eye and includes any solution used for that purpose.

In the employment of these detergent and antiseptic lotions to the eye attention has been directed to the advisability of warming them to the temperature of the human body. Albrand has invented a small instrument by which the antiseptic liquid can be raised to the desired temperature.

A. Duane[1] is careful to direct that they should be filtered and tells the patient to examine them from time to time and make sure that no precipitate has formed. If a precipitate does form, the solution is either to be filtered or, better, made up fresh. He is convinced that the precipitation of fine crystals from collyria is often the reason the latter are not well borne.

The term *collyrium* is also used to include *oily solutions* whose value is considerable. Merck's *Bericht* says that they have a much more marked effect over aqueous solutions in being less irritant in their action and less liable to decomposition. Panas and Scrini[2] pointed these facts out some time ago. On the other hand, the preparation of an oily alkaloidal solution requires the greatest possible care, to ensure that it will fulfil its object perfectly. Above all only the free bases, and not the salts of the alkaloids, must be used, as the latter are not soluble in oils. This method is used in the solution of eserine salicylate by warming in olive oil at 150-158° C. Whether this alkaloidal salt will put up with such bad treatment without becoming in part decomposed remains to be demonstrated. The fact is that eserine salicylate is not completely dissolved under these circumstances, or it is in part thrown down again when the mass has become cold. To employ a preparation of this kind in ophthalmic practice appears to me to be risky since it is impossible to know how the products of decomposition will behave. It is equally undesirable to attempt to prepare solutions of the sulphate, chloride, etc., of eserine and of other alkaloids by a method of this kind. Whether the oleates and stearates of the alkaloids are suitable for oil collyria is equally open to question; they are certainly soluble in oil, but it is necessary to determine whether the fatty acids are not irritant.

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[1]Duane. Wood's *System of Ophthalmic Therapeutics*, p. 48.
[2]Scrini. *Repertoire de pharmaçie*, 1898, p. 321.

It is thus safest to use the alkaloids themselves which are sufficiently soluble in oil. According to Scrini[3] the following solutions are to be recommended for practical purposes:—

Atropine alkaloid 0.2-0.5 per cent.; Cocaine alkaloid 2 per cent.; Duboisine alkaloid 0.2-0.5 per cent.; Eserine alkaloid 0.5 to 1 per cent.; Holocaine 1 per cent.; Homatropine alkaloid 0.2 to 0.5 per cent.; Pilocarpine alkaloid 2 per cent.

As solvents either olive oil or arachis oil may be used. Scrini removes the free fatty acids from these oils before use by shaking with alcohol, and removing the alcohol by heating to 120° C. A less desirable plan is first to dissolve the alkaloid in ether, to mix this with the oil, and to allow the ether to evaporate.

The finely powdered alkaloid is best rubbed up with a little olive oil; add the remainder of the oil, and gently warm it until solution has occurred. In so doing, the temperature must be regarded to suit the stability of the particular alkaloid, and the temperature must never exceed the melting point of the alkaloid. Thus for pilocarpine, which is liquid at the ordinary temperature, it is sufficient to warm the oil to 40 degrees; for atropine, cocaine, eserine, duboisine and homatropine, a temperature of 50 to 80 degrees C. is required.

Medicine Droppers, Simple Irrigation.

Even such a comparatively trivial agent as medicine droppers and *ophthalmic pipettes* should not be beneath the attention of the careful ophthalmic surgeon. In applying solutions to the eyeball with a dropper let the patient lie down or, sitting up, hold his head slightly tilted to the right (to medicate or cleanse the left eye, to the left for the right eye) and slowly drop about ten drops of the solution upon the closed lids. A pool of the mixture will form at the inner canthus and gradually overflow and bathe the eye from that point when the lids are opened. In this way the patient experiences no discomfort and will be able to rotate the eyeball in all directions so that the irrigating fluid comes in contact with the whole surface.

For the purpose of making (from discs, compressed tablets, etc.) fresh solutions and preserving them from dust and other contamination, Parke, Davis & Co. have prepared a medicine bottle and dropper, consisting of a graduated bottle with a capacity of 4 drachms of liquid. The tablets may be dissolved in the necessary amount of water, and the bottle closed by a pipette of improved form, the ground sides of which fit into the neck of the bottle as a stopper, the whole forming an airtight container. The pipette is closed at the top by means of a rubber diaphragm which, when pressed down and

[3]Scrini. *Bulletin Commércial*, 1906, No. 1.

then released, will cause some of the solution to ascend the tube. By again gently pressing the diaphragm, one or more drops can be easily forced out.

Chalk's bottles (England) have a rubber cap on a hollow stopper and may be either of clear or amber glass for eye-waters and similar lotions. They are often surrounded with metal cases that may be sterilized and are durable and suitable for traveling.

A very convenient form of eye-dropper is a test-tube with a spout half way up the side of it. In this eye-drops may be warmed if desired and by simply inclining the tube the patient can instill the

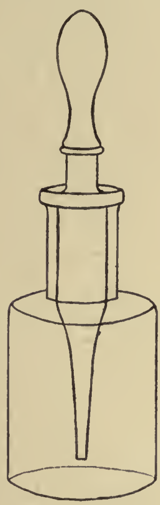

Fig. 130.
Bottle and
Medicine Dropper.

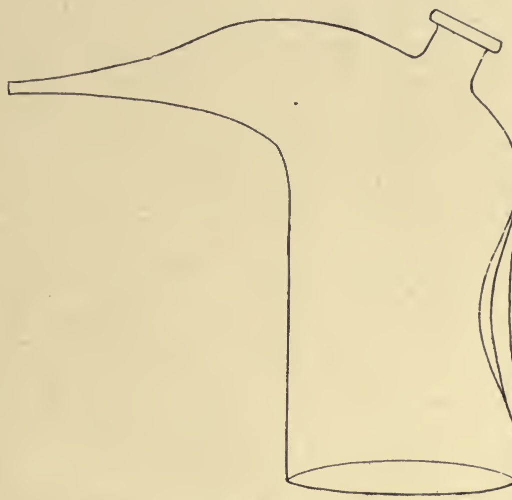

Fig. 131.
Undine.

drops into his own eye. By plugging the point-end with sterile wool a solution may be kept sterile.

Single drops are instilled with best results by forming a drop at the end of the pipette and simply touching the edge of either lid with it. If the remedy, eserine or atropine, for instance, is to chiefly affect the internal eye, the method of instillation should be different. In that case the upper lid-edge should be drawn away from the globe —the patient looking down—and the single drop applied to the raised margin beneath the eye-lashes. The watery solution flows over the upper palpebral surface to the upper sulcus, thence over the globar surface to the lower cul-de-sac, by which time it has been evenly distributed over the largest possible absorbing area, leaving little or none to flow through the puncta into the nose.

This consideration is of some importance when powerful rem-

edies like duboisine, eserine, hyoscine, cocaine, atropine, etc., are employed for long periods or in strong doses, and one is desirous of avoiding their constitutional or toxic effects, or where, as in the case of homatropine and other expensive remedies, the fullest effect is required from the smallest dose or weakest solution. In both instances this plan serves to promote complete absorption and the maximum local effect of the instillation.

In many cases of sensitive eyes, or still more sensitive patients who complain that a collyrium irritates, the eye-water should be warmed. As it is not feasible to warm the bottle each time drops out of it are to be used, the medicine dropper may be completely filled with very hot water, then emptied and a few drops of the collyrium drawn up into the pipette. The heat of the glass will be sufficient to warm the eye-water, when it should be immediately instilled.

To insure slow and complete absorption of remedies it is a good plan to dissolve them in, or mix them with, some oily or fatty menstruum, such as olive, almond or castor oil, vaselin, lard, etc. These oily solutions and ointments form most valuable applications in chronic diseases of the eye.

Simple irrigation of the conjunctival sac and the anterior surface of the globe for sterilizing purposes and for the removal of discharge and other accumulations, is accomplished by means of weak solutions of any one of the antiseptics used in ocular therapeutics, *e. g.,* bichlorid of mercury (1-10,000), normal salt solution, boric acid, borate of soda (4 per cent.), formalin, 1:5,000, or sterilized water. The lavage should be copious, and is most effective when the solution is warm.

Of the many appliances at our command one of the most useful for the purposes of irrigation is the *undine* (see the figure), although an ordinary fountain syringe, the usual hospital irrigator or a rubber tube syphon, will serve every purpose. Care should be taken that the stream of water which strikes the eye should not come with too much force and that the end of the pipette should not touch the cornea, or anterior portion of the eyeball, lest these parts be injured. Thorough flushing of the parts rather than the employment of force is the object of irrigation. The nozzle of the irrigating apparatus (the glass pipette of a large medicine dropper acts admirably) should, consequently, not be directed at the globe; it ought to be held nearly parallel with the lid edges.

In *irrigating the upper sulcus and upper aspect of the globe* the patient looks down while the upper lid is gently drawn away from the eyeball. This exposes the upper cul-de-sac to the cleansing action of the irrigating stream. To cleanse the lower sac the patient looks up

while the surgeon draws down the lower lid. The stream in most cases should be directed towards the inner canthus and not allowed to fall directly on the eyeball. If this precaution is not taken the patient will invariably resist, by closing the lids tightly, and difficulty will be experienced in effecting a thorough irrigation.

Stroschein's[4] *bottle* is a convenient holder that effectually preserves atropine, cocaine and other solutions in an aseptic condition. The figure sufficiently indicates its use.

Ampullæ.

These are specially-constructed glass bottles, hermetically sealed, for liquids likely to be injured by contact with the air or light. Most seropathic remedies come to us in this shape. Generally the container is opened by breaking its slim neck at a file-mark made in the glass.

Irrigators, Undines, Irrigating Fluids, Solutions for Douching the Conjunctival Sac, Eye-Cups and Sprays.

Although this subject will be more elaborately treated elsewhere (see the chapters by G. Byers, Ellett and Woodruff), I wish to repeat that numerous appliances for flushing the conjunctival sac. irrigating the bulbar surface and washing out post-operative and other cavities, are known to the ophthalmologist.

In addition to various kinds of medicine droppers the common glass (and rubber bag) irrigator is a valuable means of conjunctival, corneal and orbital cleansing. The glass reservoir containing the irrigating fluid, usually warmed to 100° to 110° F., is held from 1 to 12 inches above the eye, according to the needs of the particular occasion, the force of the stream and the amount of escaping fluid being regulated by a stop-cock, the thumb and finger or by some other means. All the purposes of *ordinary detergent flushing* can be obtained by raising the bottom of the reservoir a *few inches* above the level of the eyeball. The hydraulic force thus utilized is, as a rule, sufficient for complete cleansing of the parts.

The ordinary Florence flask, fitted with a rubber cork through which pass two glass tubes, one for the entrance of air, the other for the exit of the irrigating fluid, is a satisfactory and convenient vessel for conjunctival flushing and is used in some hospitals.

A glass tube, six inches long, with rounded ends, one fitting into a soft bulb holding two to four ounces of fluid, also furnishes an excellent means of conjunctival cleansing. Be sure that no rubber debris enters the irrigating stream.

[4]Stroschein. Ueber Sterilisirung von Atropin, Eserin und Cocäin Lösungen nebst Beschreibung eines neuen Tropfglases. *Archiv. f. Ophthal.*, 38, p. 155.

Irrigators for *washing out the anterior chamber* after a cataract extraction, in hypopyon, after penetrating wounds, etc., are of varied construction. Lippincott and others (see the chapter on Cataract Extraction) have devised ingenious apparatus of the kind that act with great satisfaction. Several special syringes are also used for the same purpose.

I occasionally employ a glass tube bent at an obtuse angle and terminated in a flat, rounded end about 3 mm. wide. This tube, inserted into a soft rubber bulb holding 2 ounces of water, will be found a simple, effective and easily-controlled anterior-chamber irrigator.

Fig. 132.
Stroschein's Sterile Solution Holder.

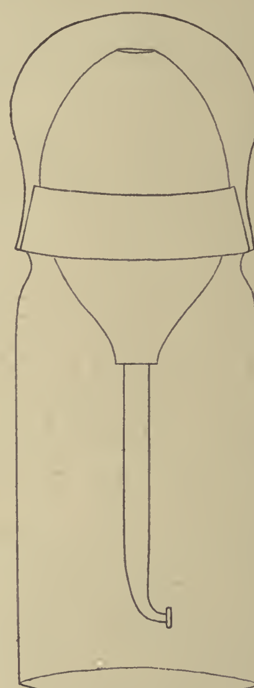

Fig. 133.
Bottle with Irrigating Syringe.

All these appliances *should be capable of sterilization and should be kept perfectly free of debris from the bulb and clean of dust,* etc. Irrigators with soft-rubber tubing or bulbs should be inspected before using to see that they harbor no particles of detached rubber, zinc oxide, chalk or other ingredients that the economical rubber manufacturer is wont to add to the rubber itself.

I wish to enter a protest *against irrigation with cotton dipped into the detergent fluid,* inasmuch as minute fibrils of the former are

very likely to find lodgment in the sac, on a roughened cornea or, worst of all, between the lips of wounds in the anterior segment of the eye.

Todd's Eye Irrigator, is a valuable means of washing and irrigating the conjunctival sac and other parts of the ocular apparatus, was suggested by F. C. Todd. The illustration sufficiently indicates the method of using it.

The ordinary *eye cup* is also a useful means of washing out the conjunctival sac. In using it the cup should be half filled with the

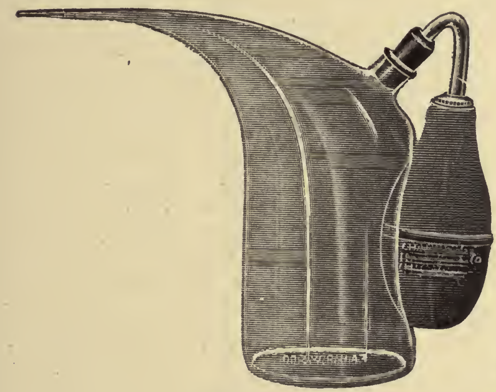

Fig. 134.
Todd's Eye Irrigator.

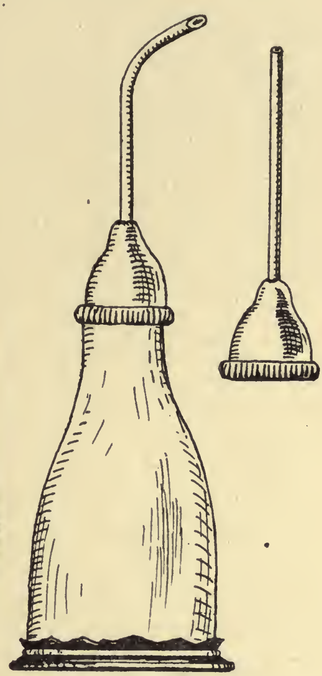

Fig. 135.
E. C. Ellett's Anterior Chamber Irrigator.

irrigating fluid, then fitted snugly about the margin of the orbit. The head should be tilted back (or the patient lie down), the previously closed eye opened and the liquid allowed to flow into the sac. Now open and close the eye slowly half a dozen times so that the irrigating fluid may come directly in contact with all the parts in and about the sac. Shut the eye, remove the cup and keep the lids closed for a few minutes.

H. C. Fenton[5] believes that instead of using the ordinary cleans-

[5]Fenton. Wood's *System of Ophthalmic Therapeutics*, p. 101.

ing collyria, that are likely to decompose, it is preferable in all cases to direct the patient to dissolve one-fourth of a teaspoonful of pure crystalline boric acid in one-fourth glass of hot water and use with an eye cup. This avoids dangers from dirty droppers and contaminated solutions.

Sprays or nebulizers, so useful in throat and nose diseases, seem to have been forgotten or neglected in ophthalmic practice. Perhaps the difficulty experienced by the patient, who cannot see precisely what he is doing during the performance, may have something to do with this unpopularity. From time to time there appear on the market ingenious devices for the purpose, but they do not have a ready sale. I have elsewhere given, and will once more repeat, the favorable experience of Claiborne in the use of certain spraying solutions and I would suggest that this method be given a trial (with an ordinary water nebulizer), in office practice especially. For home treatment there are on the market a number of pocket sprays, useful for applying evaporating lotions and collyria. The most popular irrigating fluids for detergent and germicidal purposes are weak solutions of sublimate, boric acid, borax, sodium chloride and similar salts.

At one time *potassium permanganate* was a favorite antiseptic in watery solutions of 1 to 2,000 to 500, both as a collyrium and for the treatment of lachrymal diseases, but in recent years it has fallen into general disuse. Possibly its disagreeable and destructive staining qualities and the discovery of numerous other effective germicides have had something to do with this result. Kalt, who has had much experience with the use of *large volumes of irrigating fluids* in infections of the eye, also considers potassium, calcium and zinc permanganates to be very valuable disinfectants, and advises their use—1 gramme to 3 litres of water at 25° C. One eye is to be irrigated with the solution from two to four times daily, alternating, if need be, with irrigations of warm sterile water.

One must not forget the *employment of water as a topical application,* apart from its use as a carrier of heat and cold. The rule that pure water in douches, irrigations or sprays is not a proper fluid, or is less irritant than normal salt, one per cent. boric acid, or other bland solutions for flushing or cleansing mucous membranes, to some extent applies to the conjunctiva. Yet tepid (100° F.), sterile douches of distilled water act well in washing out the sac and are most soothing to the eye, particularly in the presence of mucus, pus or toxins. It does not appear, when judiciously used in an *undine,* with a medicine dropper or in a small irrigator, to increase the mucous or purulent secretion.

Thompson[6] claims that in prescribing collyria *filtered water* is better as a diluent than distilled water since the latter acts injuriously on epithelial cells.

It seems strange that sodium bicarbonate is so little used in ophthalmic therapy, because it makes a good collyrium for detergent purposes, for irrigating the sac during the treatment of infective diseases of the eye and as a wash for the lid edges in cleansing the cilia, skin and adjoining mucous membrane from dried secretions. For all these purposes a 1 to 3 per cent. solution in distilled water is quite sufficient.

J. H. Claiborne[7] says:

"I have had rapid and satisfactory results, especially in the treatment of acute catarrhal infections of the eye by the judicious use of eye sprays. I trim the eyelashes and allow a few drops of a 2-grain-to-the-ounce solution of silver nitrate to roll over the exposed mucous membrane, then I spray thoroughly with a solution of cocaine, about ¼ of a medicine dropper-full of a 2 to 4 per cent. solution and about 15-30 drops of borolyptol to an ordinary spray tube of water. In the summer I use ice water and in the winter warm applications. I then instill a drop of adrenalin chlor. 1-1000. At times I substitute (particularly in women) 1 gr. to the ounce of nitrate of silver, and in very sensitive cases I use only the borolyptol, cocaine and adrenalin, supplementing this with appropriate treatment at home. To many people the spray is delightful; to others it is disagreeable. On trial I find I use about 20-30 pounds pressure—less if disagreable. I also find I use about 2 to 15 grains of cocaine and the same amount of borolyptol.

I prescribe a spray at home which in nervous people is easier to use than drops. I tell the patient to pull over the lower lid well and look up while some one else sprays the following into the cul-de-sac freely 3 or 4 times a day:

℞

Cocain. hydrochlor	gr. i
Sodii bicarb.	
Sodii chlorid āā............................	gr. v
Sol. adrenalinchlorid (1:1000)..............	fl. ʒi
Aquæ dest. ad.	fl. ℥i

I use the above as adjuvants in all cases of conjunctivitis, but I have found the results most brilliant in acute catarrh—particularly 'pinkeye.'"

D. T. Marshall[8] is also much in favor of the use of sprays in many diseases of the conjunctiva, (including trachoma and phlyctenular diseases) and in ulcer of the cornea. He finds that many cases of blepharitis are benefited by this method when used as an adjunct to other forms of treatment.

E. C. Ellett's *combined chamber irrigator and lachrymal syringe* resembles that formerly used by Keyser in Wills' Eye Hospital. The body of the instrument is of glass and shaped like a Gruber ear speculum with a lip surrounding the large end. The tip is of gold, fitting to the body with a friction joint. A piece of rubber dam covers the

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[6]Thompson. Wood's *System of Ophthalmic Therapeutics*, p. 53.

[7]Wood. *System of Ophthalmic Therapeutics*, p. 66.

[8]Marshall. The Treatment of Some Diseases of the Eye by Warm Medicated Sprays. *The Medical News*, Dec. 26, 1903.

large end of the body, being held by a rubber band below the lip. The tip for use in the anterior chamber is suitably curved, flattened, and of generous caliber. The lachrymal tip is smaller, rounded in cross-section, and may be straight or curved.

The manner of using the instrument is apparent at a glance. (See the figure.) Its good features are its small size and lightness, and the fact that it can be readily sterilized by boiling. It works admirably, either in washing out cortical debris and blood after cataract extraction, or inflammatory exudates in hypopyon. It is intended that a fresh piece of rubber dam shall be put on each time the instrument is used.

Eye Shades. Goggles. Enforced Rest of the Ocular Apparatus. Protective Bandages and Dressings. Collodion.

These protectives are fully described in Dr. Byers' chapter. It remains only to say that as sold in the shops *eye shades* are of almost every shape, color and size. The *Extra Pharmacopeia* divides them

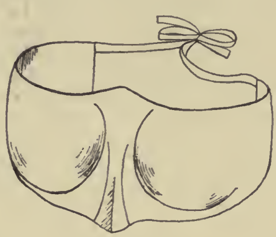

Fig. 136.
Ring's Ocular Mask.

Fig. 137.
Ordinary Eye Shield.

into the following classes: 1. Card covered with silk, flat or concave, suitable for either eye. 2. Celluloid, flesh color, for right or left eye, or suitable for either eye. 3. Of pith, the "symetrique." 4. Straw, plaited, in three sizes. 5. Double eye shades, card, pith and celluloid.

Goggles are used to guard against such outside influences (infective matter, wind, dust, strong artificial or natural lights, smoke) as are likely to irritate an inflamed or congested eye, or one that has been injured or operated on.

Rest of the eye is most effectively accomplished by paralyzing the accommodation with such cycloplegics as atropin, hyoscyamin, homatropin, and the wearing of tinted glasses, of which "London smoke" greenish and amber tinted coquilles are generally the best. This ocular "rest cure" may also be accomplished by bandaging the eyes, or placing the patient in a dark room, but neither of these procedures is desirable on account of the depressing effects on most patients. As a rule abstinence from all forms of near work, combined with an outdoor life, answers the demands of the majority of cases.

Bandages.

The *triangular bandage* is the most frequently used by me. It consists of two layers of sterilized gauze, between which is placed a layer of absorbent cotton. These are *all together* cut of the proper shape and size to cover the orbit, say about two inches in diameter. It is then laid smoothly upon the closed lids and held in place by three strips, each one inch wide, of zinc oxide adhesive plaster. Number one is placed horizontally over the supraorbital edge, the second from the nasal extremity of number one obliquely downward and outward along the side of the nose, while the third joins the temporal extremity to the lower end of the second strip on the cheek. These adhesive strips keep the dressings securely in place. Unlike other bandages, there is little or no danger of its slipping off during the night, or as a result of the patient's efforts as is apt to happen in the case of children, and some adults.

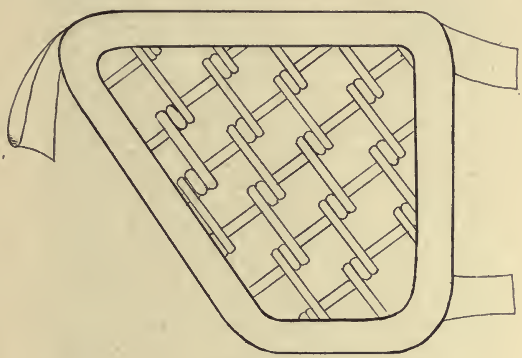

Fig. 138.
Fuchs Wire Mask.

The lids may be prevented from adhering or the lashes from sticking to dressings by applying any simple, non-irritating ointment to the palpebral margins or to the dressing itself.

Roller bandages, of gauze or muslin, from 1½ to 2 inches wide and 5 or 6 yards long, are used in ophthalmic surgery, not only as a means of protection, but for applying pressure to the lids and eyeball. For the latter purpose the depressions about the globe should be carefully and evenly filled with absorbent cotton and the bandage applied firmly about the head, and kept in place by safety-pins or adhesive strips.

The application of the bandage should begin on the forehead just over the affected eye. It ought then to be carried around the forehead across the opposite temple, obliquely down over the occiput under the ear of the affected side and thence obliquely across the

eye dressing. It should again be passed around the head, but above the ear of the affected side, then over the forehead to the opposite temple and obliquely down the occiput, under the ear on the affected side and obliquely to the eye. This should be repeated, carrying the roller alternately above and below the ear on the affected side, until the bandage is firmly applied, fixing the dressing and keeping it from slipping.

The *Moorfields' bandage* consists of a piece of linen, 3 inches wide by 7 inches long, with a notch of sufficient size in the center, into which the nose fits. Four tapes, one at each corner, are so ar-

Fig. 139.
Single Roller Bandage.

ranged that loops are formed and surround the ears. The tape is then carried singly around the occiput and forward on the forehead.

Automobile and car drivers' glasses are made of cork and mica, celluloid and concave glass (plain and tinted) for the protection of the eyes from wind and dust, that would otherwise injure the delicate corneal and other ocular tissues. They fit snugly about the orbit and are found in great variety at the optician's and motor-car shop.

Collodions.

These are chiefly solutions of pyroxylin (gun cotton) in ether and alcohol and are intended for external applications. *Cantharidal collodion* is used to blister the skin; all the other are used as dressing and for fixing them. They are to be applied by means of a small brush; the

ether and alcohol evaporate and leave the surface covered by a thin film. *Flexible* collodion is suited to abrasions, as an addition to bandages, cotton-fibre or gauze dressings in plastic operations, etc.

Local Anesthetics.

Apart from Schleich's local anesthesia method, which is fully described by Wendell Reber, brief mention of the long list of local anesthetics might not be out of order. These include acoin, alypin, anesin, brenzcain, cocaethyline, cocaine, ecgonine and its other salts, erythrophleine, eucaine with its salts Alpha-eucaine and Beta-eucaine, the latter being more effective, Beta-eucaine lactate, helleboreine, holo-

Fig. 140.
Double Roller Bandage.

caine, homocaine, nirvanin, novocaine, stovaine, tropaccaine, yohimbin, orthofrom, subcutin, anesthesin, and strophanthin.

Reichmuth[9] has investigated most of the local anesthetics and concludes that cocaine is the least harmful of them all. Dropped on the cornea they produce similar disturbances—all more intense than cocaine. Tropacocaine resembles cocaine most in this respect; cocaine alone constricts the blood vessels, all the others dilate them. For subconjunctival injections and washing out the anterior chamber, cocaine

[9]Reichmuth. Experimentelle Untersuchungen über die gewebsschädigenden Eigenschaften der gebräuchlichen Lokalanästhetika: Kokain, Holokain, Eukain, Tropakokain, Akoin, Alypin. *Zeitschr. f. Augenheilk.*, Sept. 1906. p. 213.

does least damage to the epithelium and tissues, while acoin and holocain in the rabbit produce severe inflammatory and necrotic processes, from which the eye is sometimes lost.

Darier *(Thérapeutique Oculaire,* p. 90) employs in every case where an anesthesia of short duration is required alypin or stovaine. Indeed, he believes these anesthetics to have identical therapeutic powers. If he desires anesthesia by infiltration he combines one of these agents, or both of them, in equal doses with cocaine. He also prefers cocaine in cataract extraction, and, on the whole feels sure that when cocaine is employed with proper knowledge of its advantages and disadvantages it is the best local anesthetic for surgical purposes.

Before the discovery of stovaine and alypin as local anesthetics, Schmidt[10] arranged the principal local anesthetics in order of merit from the following points of view: First, as to rapidity of anesthetic action. Of these he places first in order tropacocaine, then holocaine, then cocaine, then eucaine-A., then eucaine-B., and finally orthoform. Second, duration of the anesthesia:—orthoform, cocaine, eucaine-B., eucaine-A., holocaine, tropacocaine. Third, intensity of the anesthesia:—cocaine, tropacocaine, eucaine-B., eucaine-A., orthoform. Fourth, analgesia when the eye is inflamed:—cocaine, tropacocaine, eucaine-B., eucaine-A., orthoform. Fifth, mydriatic action:—cocaine, tropacocaine, eucaine-A., eucaine-B., holocaine. Sixth, blanching of the conjunctiva:—cocaine, tropacocaine, eucaine-A., eucaine-B., holocaine. Seventh, scleral congestion:—eucaine-A., eucaine-B., tropacocaine, holocaine. Eighth, amount of local irritation:—orthoform, eucaine-A. and B., cocaine, tropacocaine. Ninth, antiseptic properties:—orthoform, holocaine, eucaine-B., tropacocaine, cocaine. Tenth, poisonous qualities:—holocaine, cocaine, eucaine-A., tropacocaine, orthoform.

As intradermic, subcutaneous or subconjunctival injections, Darier uses a weak (one per cent.) solution of cocaine with or without acoin. The latter agent being non-toxic he has found this combination very effective and has never seen any complications from its use.

de Schweinitz refers to ocular anesthetics as follows:

"The ocular anesthetics with which one is best acquainted are cocain, holocain and eucain. Cocain is very advantageous for temporary anesthesia, but not good for continuous use, as it is apt to produce drying drying and wrinkling of the corneal epithelium, and, if anything, tends to increase the corneal ulceration if it is too constantly used. Holocain is an admirable anesthetic in a 1 per cent. solution. It causes anesthesia in from fifteen seconds to one minute, and maintains this anesthesia for about ten to fifteen minutes. Its instillation is followed by a temporary burning sensation. It differs from cocain inasmuch as it does not enlarge the pupil or increase intraocular tension, and is distinctly bactericidal. Its direct application to corneal

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[10] Schmidt. *Deutsche Medizin. Zeitung*, 1899.

ulcers has often in my hands proved most beneficial. I frequently add it to the various antiseptic collyria—for example, boric acid lotion—and sometimes apply it directly, by means of a cotton mop, to the ulcerated surface, and have never had occasion to regret a practice of this character."

Although numerous local anesthetics, especially *eucaine* and *holocaine,* have been advised as *substitutes for cocaine* it is still the favorite agent in operative procedures. I prefer (as giving the maximum anesthesia with the least cocain) for the average ophthalmic operation the following formula:

℞

Cocain. hydrochlor. ....gr. xx.
Holocain. hydrochlor. ....gr. v.
Aquæ dest. et steril. ....℥ i.

Instil one drop every three minutes for 12 minutes.

Although several observers believe that the anesthetic action of solutions of cocain, both of the alkaloid and of the salts, is lessened or destroyed by boiling, this view is not held by C. R. Holmes, who always sterilizes his solutions in this way, and has used it for operations upon the eye, ear and nose thousands of times. In his experience it is the rarest thing to find that the drug is not efficacious, and in these rare cases he has attributed its lack of action to the idiosyncrasy of the patient.

The *combination of cocaine, eucaine and other anesthetics with adrenaline, suparenine and other hemostatics* to obtain the local effects of both without inconvenience, especially during operations on the eye, of instilling these agents separately, is not to be forgotten. To supply the demand for them a number of compounds have been marketed by various chemists, although it seems hardly worth while to have dignified them with trade names. It may be observed, in passing, that Darier has set the example by giving the name *cocarenaline* to a mixture of cocaine and adrenaline, and a very effective compound it is, anesthetizing and blanching the conjunctiva and other ocular tissues, thus clearing and keeping clear the field of operation.

Verderame[11] found that the rabbit's cornea was decidedly affected by 2 to 10 per cent. solutions of *novocain.* Not only did the anterior epithelium become irregular but there were distinct erosions with marked loss of corneal substance. He found the injury to the cornea to be greater than with the use of cocaine and believes its anesthetic effect to be less.

Frank speaks favorably of *alypin.* He finds it, in 4 per cent. solution, to be free of many of the drawbacks one experiences in the use

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[11] Verderame. *Zeitschrift f. Augenheilkunde,* Sept., 1907. See, also, Sydney Stephenson's review in the *Ophthalmoscope,* March, 1907.

of cocaine; it does not dry the cornea; there is no mydriasis and no impairment of accommodation.

Sydney Stephenson makes the following emphatic statement regarding alypin: that he has never seen a bad result from 2 per cent. alypin, despite the fact that from 1905 to August, 1908, it has displaced all other local anesthetics in his practice.

Subcutin is an ethyl-erester or para-amidobenzoic acid and occurs as a white crystalline powder, soluble in 100 parts of cold and 40 parts of hot water. As a local anesthetic it is employed—generally in hypodermic form—in twelve and a half per cent. solution, dissolved in physiological salt solution.

Anesthesin is a white, odorless, tasteless powder, very slightly soluble in water but easily dissolved by alcohol and olive oil. As a local anesthetic it is valuable and employed as an ointment and in 10 per cent. strength is used as a dusting powder. In a limited way it is employed hypodermically in minor ophthalmic surgery.

Snellen *(Graefe-Saemisch Handbuch)* regards the following substitutes for cocaine as comparatively useless in practice, owing to defects in their action: Arecoline, carpeine, convallarine, drunine, erythrophleine, haya poison, helleborein, stenocarpin and strophanthin. The majority are mostly the results of laboratory experimentation and are either very irritating to the ocular structures or *their anesthetic action is not as lasting or as prompt as that of the cocaine salts.* On the other hand, he puts forward the following *claims of eucaine:* It is 4 to 5 times less poisonous than cocaine; it is not decomposed by boiling; the solutions remain fresh and active for months; it is slightly germicide; it produces neither accommodative paresis nor mydriasis; it is cheaper than cocaine.

Bruns and Robin[12] employ a mixture containing 10 drops each of a 4 per cent solution of cocaine and adrenaline chloride (1:1,000), and 20 drops of normal saline solution for inducing anesthesia in painful operations, especially excision of the eyeball. Each 40 drops of the mixture therefore contains 2/5 grain of cocaine. Ten drops of the mixture are injected deeply, behind the equator of the eyeball, along each rectus muscle. An interval of five minutes is then allowed to elapse before the operation is commenced. The method, however, is not entirely devoid of pain. Only three of Bruns and Robin's patients evinced evidence of suffering throughout the entire operation. Those who complained of pain referred it to the last stage of the enucleation—that is to say, the division of the optic and ciliary nerves. The authors noticed that robust and full-blooded men appeared to suffer more than the frail and delicate. According to Bruns and

[12]Bruns. *Annals of Ophthal.*, Oct., 1906.

Robin, the advantages of local over general anesthesia are:—the consciousness of the patient, thereby affording a safeguard against removing the wrong eye; the safety to life; and finally, the fact that most of the patients seem to prefer local anesthesia.

Painful Operations under Cocaine and Morphia Anesthesia.

Although I have not infrequently done very painful operations upon sensitive ocular tissues while the patient was under the influence of cocaine alone, or under combined cocaine anesthesia, I cannot say that I recommend the method. Ellis[13] believes that enucleation can be easily and very nearly painlessly done under the influence of cocaine if we have, first, an intelligent patient; second, a patient who has arrived at years of discretion; third, an eye moderately free from intense inflammation. In case the eye is inflamed holocain 1 per cent. may be used, since this drug acts better on inflamed tissue than cocaine. General anesthesia, of course, is best in the general run of cases, but if we have any one of the three above conditions, local anesthesia can be employed perfectly well, especially since it is unaccompanied by the disagreeable and nauseating effects of ether; and to a patient who has any real or fancied lesion of the heart, lungs or kidneys, it is as a rule greatly to be preferred. The method found to be the best is that of anesthetizing the conjunctiva with a few drops of a four per cent. solution of cocaine. The conjunctiva is then cut close to the corneal margin and dissected back until the muscles are reached. Cocaine solution from ½ to 4 per cent. is then injected along the course of the ocular muscles with a curved hypodermic or lachrymal needle, taking particular care to anesthetize thoroughly the region occupied by the entrance of the optic and long and short posterior ciliary nerves. The usual method of procedure in any enucleation is then employed. A subcutaneous injection of morphia may be given about fifteen minutes before the operation.

The following mixture, advocated by Terrien, is used to inject about the posterior portion of the globe instead of cocaine alone:

℞

Cocain. hydrochlor.	
Morphiæ hydrochlor.	āā 0.01
Stovain	
Sodii chloridi	āā 0.02
Aquæ dest.	5.00

One cc. of this solution may be injected, and the nerve cut with but slight discomfort.

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[13]Ellis. Author's abstract, *Archives of Ophthal.*, Jan., 1907.

Applications of Heat and Cold.

Heat and cold in their various forms are very common and useful adjuncts in ophthalmic surgery. The form of cold applications should depend upon the character and locality of the lesion. *Iced applications* are used in the severer forms of inflammation, when secretion is abundant, by means of gauze pads (7 or 8 thicknesses) or absorbent cotton about 2½ inches in diameter. These pads are placed on the flat and smooth surface of a block of ice, which should be large enough to hold at least half a dozen, and the excess water wrung out before applying them to the eye. They must be moist but not wet, in order to avoid the disagreeable chilling of the surface of the skin from the water running over the face. The pad should be changed frequently and as it quickly absorbs the heat from the inflamed parts, ought to be replaced by another pad with as little delay as possible, so that the eye will not be exposed any longer than absolutely necessary during the procedure.

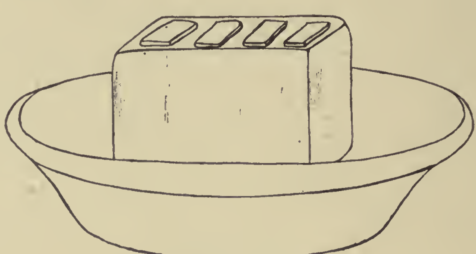

Fig. 141.
Eye Pads on Ice for the Application of Extreme Cold.

In less severe inflammations *cold* may be applied in a manner similar to that described under moist hot applications, by means of a folded towel, using a basin of cold or iced water in place of the hot water. Cold or iced applications should not, as a rule, be used as long or as often as hot applications. In the milder forms of ocular inflammation five minutes is quite a sufficient length of time, although in the severe types of purulent conjunctivitis iced applications may be kept on for a longer period. Cold applications should not cause pain or discomfort to the eye; if they do they must be discontinued, or replaced by hot fomentations. The ice pack should never be applied to the eye.

Cold is generally employed in superficial inflammation of the eyeball and lids, especially in hyperemias and inflammations of the conjunctiva, purulent and otherwise, but is to be avoided when the cornea becomes affected. It is also indicated in most injuries of the globe.

A. Duane[14] (p. c.) believes that iced applications should be used in (a) acute conjunctivitis, ophthalmia neonatorum, gonorrheal ophthalmia, traumatic conjunctivitis as long as the lids are intensely swollen. Suspend the application when the skin of the lids begins to wrinkle, showing that edema is subsiding. Use it also (b) in traumatic iritis.

In eye surgery *heat* is generally employed in the form of moist applications.

Dry heat is sometimes used, but its action does not seem to be as effectual in promoting the absorption of the products of ocular inflammation as the moist forms. Various appliances and methods of applying dry heat have been recommended, all possessing advantages and disadvantages. A simple and easy plan is to take an ordinary saucer

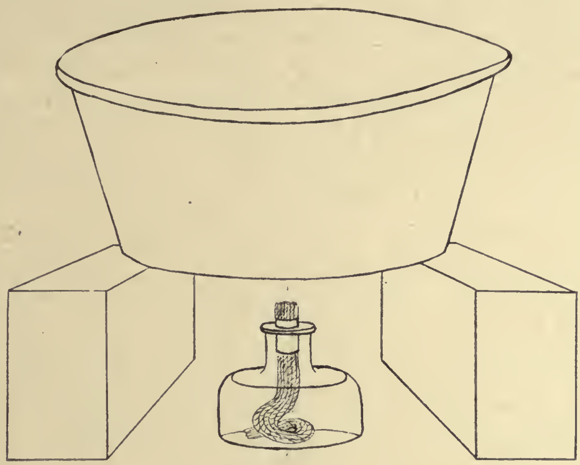

Fig. 142.
Method of Keeping Water Warm.

and place it in the oven until it is too hot to handle. It should then be wrapped in a piece of flannel, which has also been well heated, and applied over the eye and surrounding parts, previously filling in the depression around the eyeball with warm cotton wool. The whole dressing should then be kept in place by a bandage.

Several workers have devised *methods for applying heat directly to the eyeball.* For example, Ostwalt[15] has devised an appliance, which he calls a *thermacrophore,* which essentially consists of an elastic bulb, a spiral tube, and a soft rubber cup (with attached thermometer) large enough to fit over the orbit. Fresh air is driven by the bulb into the

[14]Wood. *System of Ophthalmic Therapeutics*, p. 82.
[15]Ostwalt. Des bains d'air sec surchauffé en oculistique. *Annal. d'ocul.*, March, 1905, p. 197.

spiral tube, which is placed over a Bunsen burner, and the air heated by these means is then forced into the rubber cup. The dry, superheated air can be borne at a temperature of 100°, 150°, or 175°, C. Treatment, given once or, occasionally, twice a day, is continued for about half an hour. The apparatus is intended to be used by the patient himself.

Golesceano,[16] on the other hand, attains a similar end by adopting a somewhat different plan. He applies heat to the eye by means of hot vapor. His apparatus consists of a dome-shaped boiler, connected with one branch of a double-channeled tube, of which the second branch is connected with a hand-bellows. Vapor from the boiler passes through the peripheral part of this tube, while cold air from the pump is forced through the central division. The vapor is led into a funnel-shaped mask fitted over the patient's orbit. The steam has a temperature of 40° to 45° C. Applications number one to four daily, and are continued on each occasion for from five to ten minutes. Ostwalt and Golesceano agree in finding the direct application of heat (dry or moist, as the case may be) useful in such superficial affections of the eye as blepharitis, phlyctenular keratitis, interstitial keratitis, and various forms of iridocyclitis. Roughly, then, the applications are indicated for the relief of pain and for the cure of chronic inflammations of the cornea or uveal tract.

The well-known *Leiter's coils,* made of lead tubing of a convenient size and supplied with tapes for application to the ocular region, are also quite effective as a means of supplying heat (or cold) to the eye. The reservoir is placed sufficiently above the level of the recumbent patient's face to permit of an easy trickle of water at the required temperature through the leaden coils to be received by a vessel placed beneath the bed or couch.

Hot, moist applications can be applied by means of pieces of flannel, or gauze, of several thicknesses wrung out of water as hot as can be comfortably borne. They should not be too large, although of sufficient size to completely cover the front of the eye. They should be changed quickly as soon as they show signs of becoming cool.

Hot water may also be applied with a small towel, or ordinary wash cloth, folded about three inches wide by eighteen inches long. The patient is directed to hold one end of the towel in each hand and, dipping it into water as hot as can be borne, to apply it to the closed lids and parts surrounding the eye. It is applied to the ocular region and held there a moment, the application being repeated for the length of time desired. Hot applications to be of any therapeutic value should

[16] Golesceano. Atmothérapie Oculaire. *Rec. d'ophthalm.*, July, 1905, p. 386. Also, *Rec. d'ophthalm.*, Aug., 1905, p. 449.

be employed every hour or two (depending upon the severity of the case) and for ten or fifteen minutes at a time. The temperature ot the applications should be as high as can be endured, 115° to 125° F. On account of the danger of scalding, the skin of the lids and surrounding parts should be protected by anointing it with vaseline, or some simple ointment, previous to making the application.

Hot applications are valuable in most deep-seated inflammations of the eyeball to promote the absorption of exudates, for the stimulation of the circulation and for the relief of pain. They are especially indicated in ocular headache, iritis, cyclitis, keratitis and corneal ulcer.

The Japanese "hot-box"—the small hand-warmer to be obtained in any of our "Oriental" art stores—is a favorite instrument for applying dry heat to the eye. It is readily obtained, quite effective and gives out a uniform supply of caloric for an hour or two.

A. Duane[17] advises hot (not simply warm), moist compresses in all painful and inflamed conditions of the anterior portions of the eye except when cold seems indicated or is not well borne. In cases of uveitis, etc., he thinks it is advantageous to apply hot water directly to the eyeball, drop by drop, using a solution (saline or boric acid) of 110° 115° F., or higher, as the patient develops tolerance.

Massage of the Lids and Eyeball.

In my judgment, this is a valuable remedy in most chronic diseases of the lid borders and substance, in many acute and chronic diseases of the conjunctivæ, and in the repair stages of a large proportion of ulcers and deposits in the cornea. It is also employed for the temporary reduction of the increased tension of glaucoma. It is contraindicated in all conditions in which its use is followed by much injection of the eyeball, photophobia or lachrymation.

Massage may be applied alone but is best used in conjunction with some oily remedy, or ointment, which should be made perfectly smooth and of such a consistency that it is readily distributed over the conjunctival and bulbar surfaces. It is best applied with the pulp of the finger placed on the skin of the lid. The patient is told to look down in massaging the upper lid and upper portion of the eyeball, and up in treating the lower lid and lower portion of the eyeball. In each instance the other lid should be drawn away from the one undergoing massage.

If the cornea is to be treated the patient should be directed to look straight forward. The finger movements should be fairly rapid, and made at first in a circular fashion about the cornea as a center; then they ought to radiate from the pupil to the bulbar equator in all

[17]Wood. *System of Ophthalmic Therapeutics*, p. 84

directions. In no instance should they exert undue pressure upon the eyeball. The duration of the seances must not be more than three or four minutes each, and their frequency will vary from once daily to three or four times a week. The application should never produce severe pain or other marked discomfort, although this remedy usually causes a temporary congestion of the conjunctival vessels and a slight "foreign body" sensation, both of which should pass off within half an hour after the application.

The value of this remedial measure consists in emptying the palpebral ducts (Meibomian and sudoriparous) as well as the blood and lymphatic vessels situated around the sclero-corneal margin and

Fig. 143.
Massaging the Lower Lids.

Fig. 144.
Massage of the Lids and Eyeball (Murray).

the lymph spaces in the cornea, thereby promoting absorption of any exudates that may be present. At the same time the blood vessels are still further stimulated to contraction by irritation of the vasomotor system.

Calvin R. Elwood[18] has found it of great service in chronic conjunctivitis. He feels that there is no question about the stimulation of the ocular lymphatic circulation, with consequent elimination of waste products.

Elschnig has found massage very useful in chronic trachoma with thickened tarsus, marked pannus or progressive ulcerations of the

[18]Wood. *System of Ophthalmic Therapeutics*, p. 94.

cornea that resist other methods of treatment. It is also of value in the recurrent keratitis of trachoma. He employs a probe armed with cotton which is dipped into a solution of oxycyanide of mercury (1-4,000) and introduced beneath the eyelid, the latter being mediately pressed against the forefinger of the other hand held against the outer surface of the lid. The probe is rubbed firmly back and forth against the palpebral conjunctiva. A 2 per cent. solution of cocaine is used for the first two or three sittings, after which no anesthesia is needed. An ice-bag must be used immediately after the massage. At first this is carried out every day, then every two or three days, the duration of each sitting being five minutes. In conjunction with other methods of treatment massage is useful in most external diseases of the eye (except acute trachoma), particularly in all forms of chronic conjunctivitis, when these are associated with hypersecretion or with retention of secretion in the Meibomian glands, in phlyctenular conjunctivitis, spring catarrh, small chalazion, and in certain chronic diseases of the iris and even of the choroid.

In an article on this subject I have already stated that I prefer simple massage with the tip of the finger to any form of the instrumental variety, such as direct rubbing with pieces of cotton wool, tetanization, the use of sounds and other devices. The sitting should rarely exceed three or four minutes and the best application for the purpose of pure massage is a drop or two of cod liver oil, or pure castor oil. I prefer for disinfectant or stimulating medication mercurials of various strengths combined with oleaginous excipients, such as the citrine ointment diluted with brown cod liver oil. At the end of, or during the massage, combinations of the remedy with the ocular secretions, especially mucus, should be coaxed out of the sac by means of small pieces of damp cotton and the stroking movement resumed until nothing further comes away. I find the most satisfactory employment in chronic diseases of the lid-borders and substance, in almost all the sub-acute and chronic forms of conjunctivitis, in most forms of ulcer of and deposits in the cornea, for the temporary relief of glaucoma and in some forms of retinal embolism. I believe it is useless or harmful in the early stages of acute conjunctivitis and keratitis, in most forms of true trachoma, spring catarrh, disease of the iris, ciliary body, lens, choroid, vitreous, or optic nerve. Maklakof uses the Edison spring modified for purposes of massage, the treatment lasting from five to ten minutes, the ball of the apparatus touching the eye directly. Various observers furnish contradictory reports of the good and bad results obtained from its use; most of these are favorable, especially where the treatment is employed in suitable cases;

for example, Corcashvilli reports four cases of episcleritis in which the results were very good.

Darier (*Thérapeutique Oculaire*, p. 21) advises for finger massage mercurial lanoline. This is a preparation put up by Paris druggists in gelatine capsules, each containing four grammes. He believes that the preparation undergoes slighter alterations and is more easily absorbed than similar preparations of mercury.

In this connection Darier believes that digital massage should always be carried out under the immediate supervision of, or, better, by the surgeon himself. Otherwise it is likely to be useless or harmful.

Vacher uses for the same purpose what he calls compound gray oil. This, Darier says, has about the same formula as his mercurial lanoline.

Stephenson advises the use of a one per cent. ointment of the subacetate of lead in follicular conjunctivitis. A small piece is applied to the everted conjunctiva once a day. After two weeks' time the strength of the ointment is doubled, the application being followed by massage. Under this treatment the hyperemia disappears, the dis-

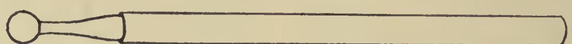

Fig. 145.
Corneal Masseur.

charge is less, the follicles become reduced in size and eventually disappear.

Leartus Connor[19] is in favor of vibratory massage and has obtained definite effects from its use. It reduces the tension of the eyeball, improves intraocular circulation and increases the activity of all the living cells in the uveal tract. It frequently improves defective vision when other remedies have failed.

Domec[20] uses an elliptical eye-cup with concave margins to fit snugly about the globe. He exhausts the air with each inspiration of the patient, exercising 50 to 200 tractions at a sitting. In nervous asthenopia, in glaucoma and infectious cases associated with severe pain this method relieved the pain. It can be employed as a preliminary measure to pressure massage or as a substitute for the latter. The analgesic action he attributes to traction on the ciliary nerves.

Brushing, Swabbing, Grattage, Brossage.

This minor surgical remedy is confined to the mechanical removal of diseased tissue from the conjunctiva, with or without the application to the partially denuded area of antiseptics or other medication,

[19]Wood. *System of Ophthalmic Therapeutics*, p. 96.
[20]Domec. *Oph. Klinik*, No. 22, 1906.

and is an effective remedy in several diseases of the lids. In trachoma (see John Green's chapter) with exuberant folliculitis, the evulsion (under alypin or cocaine) of the granulations with the thumb-nail (a rather barbarous method), with a tooth-brush, with gauze on the end of a probe, not to mention special forceps and other appliances invented for the purpose, is generally followed by excellent results. If applications are subsequently made it is well to wait until the bleeding (to which the beneficent results are in part due) has entirely stopped. Then gauze is wrapped about a wooden spatula and dipped in the remedial agent (tincture of iodine, 1:3,000 bichloride or cyanide of mercury, 1:2,000 formalin, glycerite of tannin, etc.) is gently rubbed over the diseased membrane.

Swabbing without preliminary curetting, grattage, brossage, etc., is a valuable means of thoroughly applying many remedies both liquid and solid. Cotton or gauze wrapped about wooden, glass or other applicators and dipped into the solution or fine powder forms an excellent means for these procedures.

Camel-hair pencils though effective are less cleanly than this method, unless they are renewed at each application.

Lymphagogues.

By far the most important local agent of this class is *dionin,* the so-called ethyl morphia hydrochloride. It was first introduced by Merck under its trade name and was made by the action of ethyl iodide on morphia.

It is a fine, white, odorless, crystalline powder with a slightly bitter taste, soluble in seven parts of water and four of alcohol. It melts and decomposes at 125° C. (257° F.). It is incompatible with alkalies and their carbonates.

Dionin, for which we are clinically indebted to Wolfberg, is one of the most valuable analgesic remedies we possess for the relief and curative treatment of corneal ulcer, acute glaucoma, iritis, scleritis and other inflammatory disease of the uveal tract. The relief given to the pain in most cases is prompt and complete. It may be used hypodermically (as an adjunct to atropia) but is commonly employed as a collyrium in 5 or 10 per cent. solution. The greater the edema of the conjunctiva the more decided is the analgesic action of the agent. I have never seen any ill effects from its local use, even when the conjunctivæ and lids are much swollen, nor when the saturated solution or the powdered drug has been employed at intervals for a long period. Indeed, there is every reason to regard this drug as among the best of the recent additions to the therapeutic list.

It is good policy for the surgeon to make the first application of dionin himself that he may take note of its effect and thus gauge the

strength of the subsequent doses. And that he may explain to the patient that the swelling of the conjunctiva and eyelids is a *sine qua non* of the treatment and that these apparently alarming symptoms will shortly subside with benefit, and not harm, to the eye. I have known patients seek the service of "another oculist" because of neglect of this precaution.

It must be remembered, in the administration of dionin, that one should begin with the smallest dose that will produce a decided swelling of the conjunctiva and not increase it until it begins to fail (as it commonly does). To produce the desired chemosis of the conjunctiva or to relieve the pain, I have not found it of much value in the clearing of true scars, although keratitic infiltrates often disappear, especially when used in conjunction with massage with mercurial ointments.

Undoubtedly dionin solutions—5 per cent. is a good average adjuvant—increase the analgesic and other effects of several important alkaloids used in ophthalmic practice. This is notably true of eserine and atropine, and is a most valuable advantage.

Dionin has been shown to have a favorable influence on the healing process after operations and injuries. It also assists the action of atropine and of antiseptic compresses in this way, so much so that in many cases it seems to be indispensable. The action of the preparation in corneal ulcer, opacities and infiltration (including their after-treatment) has resulted in an acuity of vision seldom attained without its use. The action of the remedy may be regarded as sufficient as long as its use is followed by chemosis, redness, and by burning sensations for 1 to 2 minutes afterwards. Under these circumstances it may be instilled once a day; as soon as they decline it is used every second day, or twice a week. The mode of administration must be selected to suit the condition of the eye at the time. It may be dusted in with a brush in the form of a powder, or it may be applied mixed with yellow mercurial ointment.

von Arlt and Foerster both recommend, as one effective means of breaking down adhesions between the iris and the capsule of the lens resulting from iritis, to place some powdered atropine in the sac and then follow it, a few minutes later, by a little powdered dionin.

A combination of dionin with pyoktanin has been found useful by Wicherkiewicz in various suppurative conditions of the eye. A 1:500 solution of pyoktanin is first instilled, and dionin is then dropped in. The latter is used in increasing strength from time to time because of the well-known tolerance that is soon established.

The ointment form of exhibiting dionin is popular with several surgeons who prefer it in the proportion of 0.25 to 0.75 grm. to 15 grm. of petrolatum—4 to 12 grs. to the half ounce.

J. M. Woodson[21] has had excellent results in the treatment of corneal opacities from the local use of dionin in the form of powder. He has noticed that the improvement continues as long as the drug produces irritation of the cornea and conjunctiva.

H. V. Würdemann[22] uses it in powder form applied to the conjunctival cul-de-sac for the absorption of intraocular exudates.

Subconjunctival Injections.

Both as a direct as well as indirect agent, in the surgical treatment of eye diseases, these agents stand pre-eminent. This is evidenced by the fact that the reader will notice numerous references to them in several chapters of this *System*.

Solutions of common salt, bichloride of mercury, cyanide of mercury, etc., are used in a number of affections of the eyeball, as for example, in iritis, scleritis, choroiditis and retinitis, detached retina, etc. The conjunctiva should be anesthetized with holocain or cocain, the point of the sterile hypodermic needle inserted near the margin of the cornea, well into the subconjunctival tissue, and a few (3 to 10) drops of the solution injected. The pain is not severe when mild salt, borax or boric acid solutions are employed, but it is quite severe when bichloride, cyanide and *strong* (5 per cent. to 20 per cent.) sodic chloride preparations are used.

Although von Rothmond in 1866 recommended subconjunctival injections, using them for the removal of corneal opacities, to Darier[23] is due the credit of definitely stating the conditions under which solutions (especially of mercuric chloride) can be best employed in this way. He used as strong a mixture as 1:1,000. The eye was cocainized and a syringeful injected beneath the conjunctiva 7 mm. from the sclero-corneal junction. Very little pain or irritation followed and Darier then and since has recommended the bichloride treatment in cases of incipient creeping ulcer, minor degree of parenchymatous keratitis, acute choroidal infiltrations, luetic disease of the eye and *infected traumatic lesions*. The injections are given daily or less frequently in full or decreasing doses, according to the requirements of the case. Although the use of sublimate and other mercurial remedies was followed by good results in the hands of many other observers it was occasionally noticed that the injections were causing pain and set up serious reactions. For this reason and because it was believed that the value of the subconjunctival injections rests not so much in the specific character of the mercurial employed as in the derivative or stimulating effects upon the lymph and vascular circulation of the

[21]Wood. *System of Ophthalmic Therapeutics*, p. 458.
[22]Wood. *System of Ophthalmic Therapeutics*, p. 458.
[23]Darier. *Annales d'Oculistique*, 1893, Vol. 109.

cornea and eye interior set up by the injection, less irritating salts were employed. The experiments of Mellinger[24] showed conclusively that we can with less pain and danger to the patient, *obtain from common salt* (1:10 per cent. solution) practically *all the resolvent effects of mercuric chloride.* This safe and painless procedure has been used with some success as an adjunct to the treatment of detached retina, iritis with posterior synechia, all forms of corneal ulcer and in many cases of scleritis. In its turn it will probably, in most cases, have its place in ocular therapeutics taken by *dionin* whose action is, in some respects, similar. I am in the habit of using 1 to 5 per cent. subconjunctival salt injections as a continuation of the treatment by dionin when that drug has ceased to produce the conjunctival edema without which its therapeutic value is practically nil.

Darier *(Thérapeutique Oculaire,* p. 32) in addition to its employment in hypodermic and intravenous injections (0.06 to 0.08 centigramme) advocates the use of *enesol* subconjunctively, and believes it likely to replace mercuric cyanide and other salts of mercury for all these purposes. It is less irritating and less painful and gives excellent therapeutic results.

In *detachment of the retina* (q. v.) subconjunctival salt solution, as an adjunct to other treatment, should begin with the usual one per cent. solution and be gradually increased until 3, 4 or even 5 per cent. strengths are employed.

This method of exhibiting various ophthalmic remedies undoubtedly possesses virtues superior to the ordinary plan of instillation or massage. It has been demonstrated that the good results so often seen are, in some instances, due to a form of local counter-irritation combined with an increased ex- and endosmosis.

This is, perhaps, the reason why the subconjunctival use of normal salt solutions is generally as effective as the use of 1:10,000 peroxide or cyanide of mercury solution. Almost every agent ordinarily effective in ocular diseases has been used in this way and as the local irritation is generally slight and the effects, when the method is rationally employed, are good it ought to have a wider vogue.

T. A. Woodruff[25] first drew my attention to the employment, subconjunctivally, of the following mixture in iritis, corneal ulcer, etc. I find that it acts remarkably well, produces very little local irritation and is *an improvement on salt solutions and any mercuric preparation* that I have hitherto used. The formula is as follows:

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[24]Mellinger. Experimentelle Untersuchungen über die Wirkung subconjunctival injicirter Kochsalzlösungen auf die Resorption aus der vorderen Kammer und dem Glaskörper. *Archiv. f. Augenheilk.*, 32, 1896, p. 79.

[25]Woodruff. Wood's *System of Ophthalmic Therapeutics*, p. 70.

℞

Iodin.	gr. 1-7
Potassic iodid.	gr. 1
Aquæ dest.	fl. ℥i

In serpent ulcer, in *infections following cataract extraction*—indeed, *in any severe purulent process involving the eyeball*—H. W. Woodruff[26] strongly recommends subconjunctival injections of mercuric cyanide, after the method of Bourgeois, as follows: The conjunctiva is anesthetized by three or four instillations of 4 per cent. cocaine solution during ten or fifteen minutes. Then eight minims of a solution of cyanide of mercury, 1 to 1,000, with four minims of 4 per cent. cocaine added, are injected beneath the internal conjunctival cul-de-sac with the hypodermic syringe. When the needle comes in contact with the external wall of the orbit the point should be turned slightly inward and the needle plunged deeply into the tissues, so that the injection is more than subconjunctival. The tissues of the orbit surrounding the eyeball are bathed with this solution. The swelling and edema which follow are quite severe, but this is probably beneficial rather than harmful. He has used these injections in thirty cases with signal success.

That the subconjunctival use of powerful antiseptics is occasionally followed by disagreeable results is well established. For instance de Schweinitz[27] noted a case of intraocular tension following a subconjunctival injection of a solution of mercury cyanide. The patient, a man, 29 years old, had a marked uveitis of the left eye which had begun with a conjunctival hemorrhage, and later a hemorrhage into the vitreous had occurred. His general condition was good. Vision of the left eye, after correction of 1 D. of hyperopic astigmatism with its axis 180 was normal, vision in the left eye was 6-60, tension below normal, anterior chamber deep, iris discolored and its pupillary area thickened and elevated. There was a fine, punctate keratitis, the vitreous was filled with thick opacities through which the fundus showed dimly, revealing a disk with blurred margins and very dark, tortuous veins. There was a marked contraction of the visual field on the upper and temporal sides. Scopolamin mydriasis, mercurial inunctions followed by iodide of potassium and pilocarpine diaphoresis gave very satisfactory results, and vision finally rose to 6-20.

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[26]Woodruff. Wood's *System of Ophthalmic Therapeutics*, p. 73.

[27]de Schweinitz. Acute Rise of Intraocular Tension Following a Single Subconjunctival Injection of a Solution of Cyanid of Mercury. *Ophthal. Record*, April, 1907, p. 165.

Antiseptics.

As stated in my *System of Ophthalmic Therapeutics*, the most valuable antiseptics are those agents that are found by experience to act best as germicides. The delicate structures of the ocular apparatus require, however, the kind of care in their application that is not called for elsewhere, so that it is not always compatible with safety to employ the same anti-bacterial remedies (or at least not in the same dosage) that are indicated in wounds or other lesions of more resisting tissues. For example, mercuric bichloride and carbolic acid are well tried and useful antiseptics, but they cannot be properly used in the conjunctival sac in anything like the strong solutions which one would apply to the tissues of the arm or leg. The desire to kill *all* the pathogenic bacteria that infest the eye—as in a laboratory experiment—induced early clinicians to use the most powerful and effective germicides, but it was soon demonstrated that it is not only impossible to sterilize completely the conjunctival sac and the surrounding tissues, but that the attempt to do so is likely to bring about vascular disturbances and other changes that are more productive of harm than the disinfection of the ocular tissues does good. This is especially true of operative procedures; strong antiseptics destroy the vitality of the wound edges, delay healing and actually invite infection.

The importance as well as the difficulties of rendering the conjunctival sac antiseptic is illustrated by the calculation of Novy that thirty billions of bacteria contain about 1-400 grain of organic matter, an amount too small to be appreciated by our unaided senses.

The list of antiseptics used in ophthalmic surgery is a long one. Among them are boric acid, picric acid, airol, airoform, alphozone, amyloform, *lotio nigra, aqua sublimatis,* most of the silver salts, aristol, aseptol, berberine and hydrastine with their salts, betanaphthol, blenol, boro-borax; borol, boroglycerite, oil of cade, calomel, calomelol, cerevisine, chloral hydrate, chlorine water, copper sulphocarbonate, creolin, europhen, formalin, gold chloride, gujasanol, Guthrie's salve, hydrastine, hydroquinone, ichthyol, iodine and its preparations, most of the soluble salts of mercury, the birchloride, benzoate, cyanide, oleate, oxycyanide, iodides and oxides, monochlorophenol, phenoalyl, several potassium salts including the chlorate and chloride, protargol, pyoktanin, blue and yellow, quinine and its salts, quinosol, radium, resorcin, salol, sodium benzoate, benzosulphinide, borate, chloride, saccharate, salicylate, sozoiodolate, sulphate and chlorinated soda, sophol, sozoiodole-zinc and mercury, sublamine, thigenol and trikresol.

It may be well to say a few words about some of the more important antiseptics in the foregoing list. Of prime importance and tried

efficacy are several *salts of mercury.* In this connection it has been noticed that the more mercury a preparation contains the more powerful is its disinfectant action. The best known of these salts are the bichloride and oxycyanide. Schlösser advises the latter in 1 to 2 per cent. watery solution and says that it may be used in any capacity to which sublimate is adapted and that it is not so irritating to the ocular tissues.

Formalin, 1:1,000 to 5,000, salicylic acid (3 per cent.), pyoktanin, boric acid (3.5 per cent.), *chlorine water* (2 to 5 per cent.), *potassium permanganate* (1:1,000 to 4,000), sodic benzoate (five per cent.) and a saturated solution of hydrogen peroxide in water, to which may be added various antiseptic preparations of salts of metals, (iodine, silver, copper, zinc) and many organic compounds also belong to the class of astringents or caustics. A third class of antiseptics include such neutral bodies as vaselin, paraffin, castor oil, glycerine, etc., that act indirectly as antiseptics by furnishing a soil but poorly adapted to the growth of some pathogenic bacteria.

Preparations of certain aniline dyes were, as germicides, introduced into the local treatment of eye diseases by Stilling.[28] They were very popular for a time, especially the yellow and blue pyoktanin, both of which in the solid form and in all their watery solutions were widely used. Interest in them has been more recently revived by Rudini and others but it has again waned. *Methylene blue and toluidine blue* are also employed by some ophthalmic surgeons in corneal ulcer and in infective conjunctivitis.

Clarence P. Franklin[29] reports of *toluidine blue* that "after ten years' use of this drug the statement seems warranted that it is a most efficient remedy in muco-purulent conjunctivitis and is practically a specific for the Koch-Weeks and Neisser forms of the disease. The usual ten days to two weeks' discharge of "pink-eye" is reduced to four to six days and with this treatment there seems to be less chance of a fresh infection; at least the writer has never seen a return in any instance among many cases.

In ophthalmia neonatorum and gonorrheal ophthalmia of the adult the purulent process is markedly and rapidly lessened.

It is to be used three times a day (in 1:1,000 solution, dropped into the conjunctival sac) and alternated with solutions of adrenalin and boric acid. This treatment has given uniform results with no untoward symptom except that, rarely, a patient of pronounced susceptibility complains of slight stinging on its first instillation."

Zinc permanganate, as dark violet-brown, hygroscopic, crystalline

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[28]Stilling. Les Couleurs d'Aniline Comme Antiseptiques. *Revue gén. d'Ophtal.,* April, 1890, p. 145.

[29]Franklin. Wood's *System of Ophthalmic Therapeutics*, p. 45.

granules, similar in appearance to permanganate of potassium is, like it, used as an antiseptic and astringent wash. It is employed as a bactericidal collyrium in 1 : 1,000 to 500 solutions and should from its chemical composition be very useful clinically. I have prescribed it with much benefit as a 1 :3,000 solution for the home irrigation of the nasal duct following operation for the relief of lachrymal stricture.

The problem of obtaining the complete antiseptic action of sublimate upon the ocular tissues without disturbing unduly the vascular supply of the parts and without inducing discomfort, is solved by the use of *an ointment,* first proposed by J. A. White. He found that while it is impossible to use, especially in operative work, such decided germicide solutions as 1 :3,000 in water that strength might be employed as an ointment with vaselin. His formula is:

℞

Hydrarg. bichlor. ....gr. 1/6
Sodii chlor. ....gr 5/6
Alcohol dil. ....q. s.
Petrolati ....℥i

Dissolve the sublimate and the common salt in a few drops of dilute alcohol and mix with the vaselin, which has been perviously kept at a temperature of 212° F. for half an hour. Stir until cool. This may be put into soft capsules for individual use, or kept as an antiseptic base for atropine and other ointments. I have prescribed this salve and used it extensively in private, dispensary and hospital work and can recommend it as a most useful application to the sac when a reliable antiseptic is desired. It is my practice to fill the sac with the ointment twice in 24 hours as one of the preliminaries to major operations of the globe. I also prescribe it extensively alone and in conjunction with other remedies for the home treatment of several forms of blepharitis.

Stieren (first and after him Lippincott) advised a *modification of the ointment* especially in infected ulcers of the cornea, *by the addition of lanoline,* which takes up the watery solution of the bichloride better than vaselin alone. One formula follows:

℞

Hydrarg. bichlor. ....gr. i
Sodii chlor. ....gr. vi
Petrolati ....℥ii
Lanolin ....℥iii

Paraffin and Gelatine Injections.

Various paraffin and gelatin mixtures, as well as several varieties

and combinations of these agents, are occasionally employed as subcutaneous and submucous injections in ophthalmic surgery. Their usefulness is mostly confined to *supplying defects in the osseous structures of the orbit* or in the neighboring facial bones; in *filling the lachrymal sac,* so as to outline it, *prior to removal;* for the *relief of "saddle-nose,"* that a pince-nez glass may be worn and, occasionally, *after enucleation and orbital exenteration,* to assist in the fitting and wearing of a prothesis.

Gersuny (Ueber eine subkutane Prothese. *Zeitschr. f. Heilk.,* 1900, Vol. 1, Part 9) was the first to employ this method and to give his experience of these injections on the bodily tissues. The injected

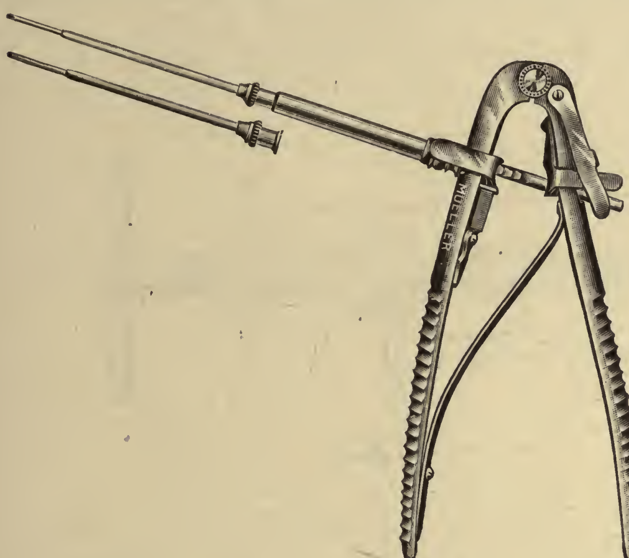

Fig. 146.
Beck-Mueller Paraffin Injector.

material acts immediately by filling a void and eventually by stimulating cell growth, especially of connective tissue, so that a permanent (cartilage-like) increase in the volume of the parts is brought about.

A stout hypodermic syringe or, better, one of special construction may be used and any of the agents mentioned injected. White vaseline with a melting point of about 40 degrees C., is recommended by Elschnig. This is carefully sterilized, warmed in a water-bath and under the most careful aseptic precautions, the syringe point is introduced down to the periosteum. The piston is then withdrawn a little to make sure that the terminal has not entered and is not lying in a bloodvessel. If no blood is withdrawn the body of the syringe is removed from the point and filled with the warmed, semi-liquid vaselin. *The assistant*

now presses with his forefingers on either side of the area to be injected. About half the barrel of the vaselin is now injected, the needle-point extracted, the finger placed over the wound of entrance and the part gently massaged, to distribute the vaselin as desired. Then the parts are sprayed with ether, to cool them off and harden the vaseline, sticking plaster is placed on the wound, and the assistant's fingers are removed for the first time. The injected area is red and sensitive for a week or ten days. The operation may be repeated in about six weeks, if needed.

Injections into the *soft tissues* of the lid and orbit are objectionable. They do not answer any good purpose and the reaction is frequently dangerous.

For *injecting the lachrymal sac,* many instruments have been devised. Whatever syringe is used one should beware of employing

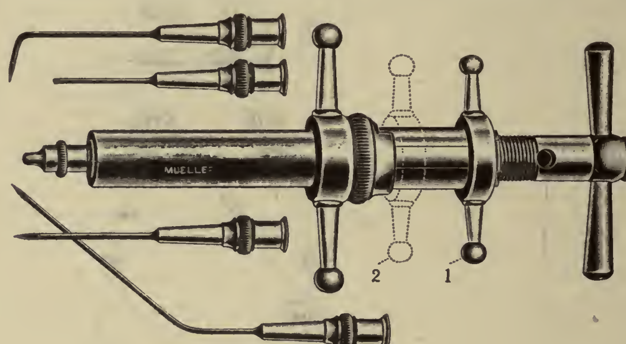

Fig. 147.
Broeckaert's Paraffin Injector.

force, it matters not what agent is used. Spermaceti (Valude), iodide of starch (C. R. Holmes), paraffin whose melting point is 110 to 120 degrees F. (Wilder), various forms of gelatine (colored or plain), dental plaster (Fullenwider), or the low melting point paraffin mixtures recommended by Gersuny, von Pflugk, and others have all been successfully employed.

Other powerful syringes besides those already mentioned are Beck's and Broeckaert's. The illustrations fully demonstrate their *modus operandi.*

The difficulties attendant upon the injection of solid and semisolid paraffin and gelatin mixtures is overcome in Pflugk's[30] injection apparatus. He uses it for mixtures whose melting point is not below 42° C. As shown in the figure a strong syringe is surrounded by a

[30]Pflugk. Ein Beitrag zur Technik der Injektionen von Paraffinum solidum. *Deutsch Med. Wochenschr.*, No. 23, 1902.

water-coil carrying fluid sufficiently hot to render the paraffin liquid or semi-solid. The needle 25 mm. long is fitted to the barrel by a bayonet joint. The water flowing through the jacket should be between 50 and 60 degrees C. The material should be injected slowly and steadily, without strong pressure and only a few drops at a time, so as to give time for its hardening *in situ.* The inventor advises that not more than 20 drops be injected at one sitting. If used in this way the little operation is entirely without danger of embolism or other untoward accidents. The complete instrument may be had from Windler, Friedrichstr. 133a, Berlin, Germany.

Probably this apparatus could also be employed for *intramuscular injections* of gelatine in the treatment of *orbital aneurism* (q. v.).

Intravenous Injections.

The injection directly into a superficial vein of the upper arm of various soluble salts for the purpose of *obtaining a more rapid or more pronounced remedial result in eye disease* has been highly recommended by several surgeons of repute—notably by members of the French School of Medicine. The following estimate by Darier *(Thérapeutique Oculaire)* of this kind of medication is well worth consideration.

Injection of the soluble salts of mercury, and particularly of the cyanide, is a difficult procedure, but in skilled hands has advantages of the first order, *i. e.,* absence of pain; rapid and exact action; no local lesions (infiltrations, etc.) so often following intramuscular injections, and *no serious sequels.*

The solution should be thoroughly aseptic, and contain no cocain or any other analagesic, as these act violently on the heart and nervous centers. The solution he recommends is as follows:

℞

Hydrarg. cyanid.	0.33
Sod. chlorid.	0.08
Sod. phosphat.	0.07
Aquæ dest. et steril	100.00

Two or three cc. are to be injected into one of the veins at the bend of the elbow, taking care to give the injection slowly.

The technic is simple, almost as easy as intramuscular or hypodermic injections. There are persons in whom the veins are difficult to find. In these cases it will be necessary to have recourse to subcutaneous or intramuscular injections.

Proceed as for a phlebotomy, when one applies one or two turns of a bandage tightly around the arm above the biceps. During the venous stasis, wash the site of the injection with cotton soaked in

chloroform, alcohol or sublimate. Pass a fine platinum needle with iridium point through a flame; then introduce it cautiously into the vein. Before injecting aspirate slightly to see if the blood can be drawn into the syringe. If blood appears in the syringe one can be sure that a false passage has not been made. The bandage is then released, and nothing remains but to slowly (4 or 5 seconds) push the liquid into the vein. The patient complains at most of a sensation of chilliness; or occasionally of a taste of bitter almonds. The needle is to be withdrawn quickly, and slight compression made with a tampon of cotton over the puncture. A drop of collodion will then seal the orifice.

Make the injections in each arm alternately so as not to weaken the vein, which after a great number of punctures will thicken, and at that spot become painful to further injections. This is the chief objection that has been made to intravenous medication, but it is always time to return to the hypodermic plan when the venous method does not permit the continuance of the treatment.

Nervous patients have, the first time, some apprehension, especially if the injection is made too rapidly or if it seems to them that the physician is not sure of himself, but such drawbacks are entirely compensated by the advantages.

In using cyanide of mercury, one should not neglect before each new injection to ask of the patient if *he has experienced* since the last injection any *colic or diarrhea*. In either event the dose should be diminished or the injections made less frequently.

After the first series of thirty injections they should be discontinued for a month; then resume with a second series, and even a third. Sometimes, in certain chronic affections like keratitis parenchymatosa, choroiditis and irido-choroiditis, one may be obliged to give, in the course of two or three years, from one to two hundred injections.

Darier has given thousands of intravenous injections, without complication, except occasionally a slight periphlebitis, where a little of the liquid had escaped outside of the vein. The entrance of air bubbles into the veins of the arm is without danger; he has injected a syringe full of air without inconvenience.

Complications are exceedingly rare. An infectious phlebitis has never, Darier maintains, been observed, and it is hardly possible if the needle has been previously sterilized by heat. He has found it well, to prevent the rapid tolerance established by the organism to any one medicinal agent, either to vary the mode of application (inunctions, hypodermic injections, deep injections, sub-conjunctival injections), or to change the salt. Thus, he makes a first series of twenty to forty intravenous injections of the cyanide of mercury; then allows

three months of rest; then he gives a new series with a biniodide (0.01 increasing gradually to 0.03). If a third series is necessary, and we have to deal with one of those forms of tertiary syphilis with intractable cutaneous complications, or bony lesions, he has recourse to another salt of mercury, *enesol for example.*

Enesol is a salicylarsenate of mercury, very soluble, rapidly eliminated by the urine, seventy times less toxic than the biniodide, and is employed for injection in a 3 per cent. solution. It causes little pain.

A centigramme of enesol is equal to 0.0087 of the biniodide. A cubic centimeter of the 3 per cent. solution contains 0.0115 of metallic mercury, corresponding to 0.026 of the biniodide.

Darier has given intravenous injections of enesol of one to two cc. with most favorable therapeutic results, and has also employed it in subconjunctival injections frequently without provoking the least ocular or intestinal irritation. It may cause slight soreness of the gums after ten days' treatment.

In subconjunctival injections, enesol is less painful than the cyanide, while in hypodermic injections it looks as if it will replace all known salts requiring as an adjunct as analgesic of some sort; cocain, acoin, or subcutin.

The intravenous use of the mercurial salts rendered Darier such service, that after reading the essay of Mendel, he did not hesitate to administer the *salicylate of sodium by the same method.* This salt he employed in iritis, episcleritis and other rheumatic affections of the eye, 0.50 to 0.60 daily into one of the veins at the elbow. With these doses of 0.60 as the maximum, he obtained better results than with three of four grammes of the salicylate or aspirin given internally.

Credé has demonstrated the bactericidal power of *collargol* in affections caused by streptococci, staphylococci, etc. He utilized it in intravenous injections of 0.08 to 0.12 centigr. of a 2 per cent. solution, in many infectious conditions with excellent results and Darier now holds with Credé that this mode of application by intravenous injection is the only true way.

DeLapersonne has treated, by means of intravenous injections of collargol, certain forms of purulent iritis due to systemic infections. In one case the hypopyon completely disappeared, and the case was cured by a single injection.

In traumatic cases, equally good results are obtained by collargol, but if panophthalmitis has been once established of course nothing can stop it.

Intraocular Medication.

In 1887-8 Abadie and Galezowski injected a solution of mercuric chloride into the vitreous, hoping to disinfect the bulbar region by

bringing a powerful germicide in actual contact with the infected area. Although the results of this experiment were not favorable, other attempts, with weaker solutions of sublimate, cyanide of mercury, argyrol, iodoform emulsion, etc., have proved more successful. Haab, as is well known, has published encouraging reports of his method of introducing rods and discs of iodoform in substance into the ocular interior, especially to combat infected penetrating wounds of the cornea and bacterial invasions of the uveal tract and vitreous.

H. V. Würdemann[31] introduces 50 per cent. argyrol solutions into the anterior chamber through corneal incisions or wounds and has thereby saved many eyes with hypopyon iritis.

Artificial and Natural Leeches. Local Bleeding. Wet Cupping.

It is generally agreed that the local abstraction of blood is a valuable agent for the reduction of most acute, deep-seated inflammations of the eye, such as iritis, iridocyclitis, glaucoma, choroiditis, etc. The pressure exerted upon the sensitive nerve-endings by the dilated blood vessels (and increased quantity of blood in the congested tissues) is thereby removed and the severe pain which usually accompanies these

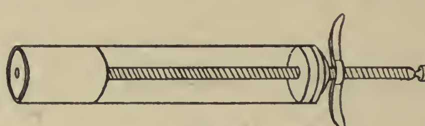

Fig. 148.
Artificial Leech.

abnormal conditions is often promptly relieved. Although there are several methods in use for the abstraction of blood in this neighborhood, such as scarification of the conjunctiva, opening an artery in the temple or the application of the leech, the last named is the most popular. One may use either the living animal or its substitute, the artificial leech. The latter is preferable, as it is not only more certain in its action and more agreeable to the patient, but the amount of blood abstracted can be easily regulated.

The artificial leech consists of a glass cylinder in which works a piston connected with a thumb screw. This is attached to the piston rod by means of which it can be raised and lowered. The skin of the temple, half an inch from the outer margin of the orbit, is the most desirable place for its application. Here the skin is first scarified, either with a small instrument containing a punch that cuts two crescentic wounds, or a number of small incisions are made with a fine scalpel. The end of the cylinder is then applied over the wound and the blood withdrawn by exhausting the air in the cylinder. At least half an

[31]Würdemann. Wood's *System of Ophthalmic Therapeutics*, p. 90.

ounce of blood should be withdrawn if a decided effect is to be produced upon the intraocular circulation.

A rubber "cup," or a glass cylinder attached to one, and a small lancet are all that are needed for cupping. The skin of the temple is highly scarified by criss-cross incisions, or by dermatone, and the blood drawn by suction. The cup of the victor or other machine, used in giving massage, may also be used.

Theobald[32] in 1875 suggested that the best result from this method of blood extraction is obtained by pinching up a fold of skin with a pair of dressing forceps and, using a Graefe knife, "nicking out" a small, thin disc of tissue, 3 mm. in diameter, involving the epidermis and superficial layers of the cutis. The suction cylinder was then employed as usual. He found this convenient, practically painless and much more efficient than the scarifier. He also found by experiment that a few drops of a 1½ per cent. solution of ammonia carbonate dropped on to the wound or placed in the cylinder of the artificial leech increased considerably the free flow of blood. There was not the usual tendency to the formation of a clot in the instrument.

Water Bags and Similar Appliances.

These convenient means of reducing or increasing the temperature of the ocular area afford one of the most cleanly means of applying dry heat or cold and of securing rubefaction. When covered with flannel or wrapped in cloth they retain the heat much longer and are much less liable to produce burns. The possibility of this accident should always be kept in mind; the bag should not be used when it is too hot to be borne for half a minute against the cheek.

O. A. Griffin[33] uses in aggravated and prolonged acute inflammatory diseases of the eye a small rubber bag through which either hot or cold water can be syphoned. To make the application more effective (by a retention of the applied temperature) a double layer of moistened gauze, about two inches square, is first placed over the affected eye and the water bag then put into position and retained in place, if desired, by means of a tape or string. Single or double bags are used, depending upon whether one or both eyes are affected. To retard the discharge of water and thus prolong the duration of application, and also to produce a distension of the bag, a tiny opening is made at the end of the discharging tube by inserting a bit of hard rubber tubing which contains a minute passage through which the water escapes. The arrangement is completed by placing two pitchers of like capacity at the proper height to produce a slow and steady flow of water from the

[32] Theobald. An Improved Method of Applying the Artificial Leech. *Am. Jour. of the Med. Sciences*, 1875, p. 129.

[33] Griffin. *Trans. Am. Acad. of Oph.*, 1906, p. 140.

upper to the lower vessel. When the upper one is nearly empty, it is only necessary to pinch the tubing or elevate the discharging end and pour the water from the lower into the upper pitcher to keep the apparatus running properly. The stream will flow from thirty to sixty minutes, depending upon the relative height of the pitchers and the size of opening in the discharging tube. By timing the process, the attendant may know exactly when to change the water, and the compress may be applied steadily and indefinitely without disturbing the eye or the patient, which is very important, especially when the patient is sleeping and rest is essential.

If cold compresses are desired pieces of ice may be added to the water, and to retain the rubber tubing in the upper vessel a foot of glass tubing is inserted into the rubber one, which also prevents collapse of the tubing should the ice press upon it.

If hot applications are indicated heated water is used instead and kept at a uniform degree by occasional additions of hot water. In his experience, unless pain demands a continuous application, the most satisfactory results are secured when the compress is employed intermittently, fifteen or thirty minutes elapsing between applications.

After the apparatus is properly arranged, the appliances for which may be obtained in any ordinary home, it requires little or no attention and, in his opinion, is the most rational method of employing heat or cold in the treatment of acute inflammatory disorders of the eye, inasmuch as the temperature is uniform, the water bag is light and conforms to the surface beneath, the compress is applied directly to the area desired, the patient is not chilled or drenched by escaping water and the application may be used indefinitely without disturbing the patient.

The electric light service also furnishes a ready means of *thermal treatment.*

A very good method of using it is that described by Maddox. He uses a half to seven-tenths ampere current passed through a very fine wire which is wrapped around a roll of canton flannel. The current can be taken from an ordinary lighting wire and controlled by a transformer. The employment of dry heat he believes is especially indicated in rheumatic affections of the eye and in certain forms of glaucoma. The indications for the use of dionin are still unsettled. As a rule the drug should be employed when heat is indicated, while adrenalin is useful when cold is the more applicable.

I exhibited at one of the meetings of the Ophthalmic Section of the American Medical Association an electric hat-iron, which is used in the manner suggested by Maddox. This appliance can be purchased at most dealers in electric supplies and is a handy and effective means of applying dry heat to the ocular region.

ompresses.

Applications to the ocular region may be made on gauze, cotton, or other medium and may comprise the whole range of ophthalmic solutions.

Chlorine compounds, well diluted, form common examples of the antiseptic compress and detergent. Buchardt, for example, advises the following mixture:

℞

Acid salicylic	0.7
Chloral. hydratis	1.5
Acid. boric	30.0
Sol. aquæ chlorinatæ (1:20)	1000.0

Alsol is generally used in the form of compresses of 5 per cent. strength; one teaspoonful to a cup of boiled water. It is said to have the advantage over boric acid and sublimate of not causing eczema of the lids when used as a local application. It is, therefore, especially valuable for compresses in blenorrhea neonatorum, in conjunctivitis, granular and scrofular ophthalmias, and in warm solution, in chronic cases; also in hordeolosis, in corneal ulcers and iritis, but in such case in solutions of 1-500 and 1-1,000. It forms an acid solution with water but is insoluble in alcohol.

Cataphoresis.

This remedy has been employed by Krückman and others who used it for introducing mercury and other remedies into the system for syphilitic and other diseases of the eye. He found, experimentally, that currents of 1.2 to 1.3 milliamperes could be applied to the eyeball without producing necrosis or any change in the finer tissues of the eye. Of the various salts of mercury, sublamin 1-3,000, and succinate of mercury, 1-4,000, were found to be the least irritating. The method is to be recommended only for rapid and temporary use, a general mercurial treatment being required at the same time. It may be used in the following syphilitic conditions: 1. In rapidly growing or early appearing nodular processes, *e. g.*, tuberous syphilide and gumma resembling episcleritis. 2. In obstinate inflammation when the body is already oversaturated with mercury. 3. For diagnostic purposes, when the general symptoms have not appeared, and it is important that they should not be masked. 4. For very rapid action. 5. In the presence of mercurial stomatitis.

It is applied by especially constructed electrodes which can be attached to the street current. A current of 0.8 to 1.0 millampere is employed for 20 or 30 minutes, and the current reversed every two and

one-half to three minutes. The treatment may be repeated every other day, and from three to ten treatments are usually sufficient. The author reports 28 successful cases.

D. S. Sager believes (Wood's *Oph. Ther.*, p. 80) after cataphoresis, if the lower canaliculus is split, in washing out the sac. He makes it a point to turn the bent tip upwards, syringing so that the fluid, argyrol or other, regurgitates through the upper canaliculus, or at least so that the surrounding tissues shall be well medicated and cleansed. Where the upper canaliculus is slit open, as advised by Landolt, the procedure is already solved. Then again in trachomatous and chronic granular conditions of the eyelid, he suggests that the cataphoretic treatment on the lids be given a fair trial. He has succeeded with it when radium, X-ray, Finsen, high frequency, etc., have all failed. The method is accomplished by placing the positive end of a copper electrode in a solution of common salt, the negative electrode also in the solution, with no contact of electrodes. When a sufficient amount of copper chloride is deposited upon the positive electrode, after wiping the lid clean with absorbent cotton, or washing off the lid-surfaces, the positive electrode is applied directly to the lid-surface for a few seconds, even to half a minute. Sometimes the lid is cocainized or otherwise rendered insensible (holocaine or eucaine). The reaction is probably considerably less than with copper sulphate stick, this, depending upon the individual somewhat.

Counter-irritants. Rubefacients.

Redness or increased redness is the result of irritation of the skin. Rubefacients cause a slight increase in the capillary exosmosis, and if the irritation be not long continued or too severe the exudate is absorbed and the parts soon return to the normal condition. They all act as counter-irritants.

Iodine, as the tincture or solution, is very effective. Several applications produce blistering or a caustic effect, but this action can easily be controlled. To remove the dark stain from the skin wash the latter with dilute solution of ammonia or a solution of sodium thiosulphate.

Other valuable counter-irritants are *Credé's ointment* (especially recommended) jequirity, abrin, jequiritol, turpentine, oil of mustard, alcohol, dionin and peronin.

Cautery.

As this subject is extensively treated elsewhere in this *System*, I merely wish to say that its importance as a minor surgical agent cannot be over-estimated. The employment of chemical cauterants and escharotics (q. v.) is often substituted for the *actual* or *galvano-cautery*, but, as a rule, these two agents are to be preferred. Instead of

making actual contact with the point of the cautery, D. W. Green[34] heats the metallic point to a cherry-red color and approaches it to within half a mm. of the corneal surface (or as near as possible without touching it) so as to destroy only the superficial debris. This method produces effective asepsis without destroying any normal tissue and no scarring results.

An excellent substitute for the galvano-cautery is the hollow needle fashioned after the Pacquelin cautery used in pyrography—"burnt wood" work. This simple device rarely gets out of order, can be had everywhere for a few dollars and, when the electro-cautery is not at hand, will be found most useful; indeed, I know several surgeons who, for various reasons, have discarded all other forms of the actual cautery and use the "burnt wood" needle instead.

Chemical Cauterants, Caustics, Escharotics.

The same introductory remark may be employed in speaking of these agents; their principal value is in the destruction of microbic depositis in corneal ulcers. Altogether they form a long list that includes glacial acetic acid, chromic acid, dichloracetic acid, hydric chloride, iodic acid, lactic acid, monochloracetic acid, nitric acid, trichloracetic acid, gold carbolate and paraiodophenol.

Iodized carbolic acid or solution of iodine in glycerine-carbolic acid, is a preparation made from iodine 20 parts, phenol 60 parts and glycerine 20 parts. Applied pure to corneal ulcers it is one of the most effective cauterants and germicides we possess. I believe it to be in that respect even better than pure tincture of iodine or pure phenol used alone. Of course, it is to be carefully rubbed into the stained, cleansed and cocainized cornea by means of a pointed tooth-pick or wooden match soaked in the fluid.

Carbolic acid is one of the most effective germicides in the pharmacopeia. I regard a 95 per cent. mixture with glycerine as a good cautery for non-serpiginous ulcers of the cornea. After staining, irrigating and anesthetizing the globe the diseased area should be thoroughly probed with the point of a wooden tooth-pick saturated (not merely dipped) in the solution, excessive fluid being removed from the tooth-pick with blotting paper. This procedure may be repeated several times if necessary. Inasmuch as the phenol whitens the ulcer area it is easy to regulate the application. Success depends upon using as little as possible of the cauterant and tattooing it well into the infected spot. There is little or no destruction of true corneal substance by the carbolic acid and, consequently, a minimum amount of scarring.

I have also found corrosive sublimate a useful application to cor-

[34] Wood. *System of Ophthalmic Therapeutics*, p. 81.

neal ulcers in a one per cent. alcoholic solution. Stronger mixtures form efficient escharotics.

Some of the important ophthalmic *caustics* are copper salts, nitric acid, fused potash, silver salts, sodium ethylate, chloride of zinc, "Vienna paste" and so called "London paste," made of equal parts of caustic soda and unslacked lime. For Vienna paste take caustic potash 5, slacked lime 6 parts and make a paste with alcohol.

Escharotics.—Agents that applied to the tissues destroy them and produce a slough or eschar. A useful escharotic is zinc chloride paste, sometimes employed for the removal of epitheliomata, tubercular growths, warts and other superficial tumors of the lid-skin.

Blisters, Vesicants.

Although this remedy is no longer used to any extent in ophthalmic operations, yet it is sometimes of considerable importance.

Vesication is the result of greater irritation than that which merely causes superficial redness of the skin. The serous exudate from the blood vessels due to blistering is not re-absorbed, but remains beneath the epidermis. Agents which produce this condition are termed epispastics, vesicants or "blisters."

If the vesicle is ruptured soon after it has formed, and its epidermal layer removed, a tender surface is exposed. This unprotected area is liable to infection, hence it is better to puncture the blister with a sterile needle inserted at the most dependent part; the fluid then escapes while the loose epidermis protects the denuded area until a new layer of epidermal cells is formed.

Blisters are useful as counter-irritants and local depletants and as such have a place in ocular therapeutics.

When it is necessary to apply a blister to the ocular neighborhood this remedy is best employed in the form of cantharidal collodion, although the "paper" cerate or plaster may be used. Any of these takes about 5 hours to produce vesication. After the application has remained *in situ* sufficiently long to blister, the vesication may be much increased by following it with a poultice. The serum should be removed from the pendant bleb by pricking it, after which a soothing cerate should be applied.

I much prefer the cantharidal collodion; it is more certain more cleanly more easily controlled and localized and probably less painful than the other form of the "fly" blister.

A non-official, rubber-base plaster containing cantharides has several advantages over that made from the cerate. After preparing the skin surface the plaster is smeared with a thin film of oil and applied. When it has blistered the part as much as required it is removed.

Anodyne vesicant is a good substitute for cantharidal collodion and is made as follows:

Camphor 20 parts, chloral hydrate 30 parts; place in a bottle, liquefy in a water bath and add cantharides 10 parts. Digest at 140° to 160° F. for one hour; strain under pressure.

Charta epispastica is paper spread with spermaceti, cantharides powder and other ingredients. This is cut into the shape and size needed and applied for blistering purposes.

Papers, Chartæ.—Our only official charta or powder is used for the application of mustard and when dipped into warm (not hot) water and applied to the skin, these applications act as a rubefacient. In prescriptions, "papers" are ordered by the square inch, thus:

℞

Chartæ sinapis ....2 x3 inches

Dip into warm water and apply to the temple.

℞

Chartæ epispasticæ vel cantharidis......2 x 3 inches

To be applied above the right eyebrow until it blisters.

Vaso-constrictors.

These remedies produce contraction of both arteries and veins of the anterior plexus, accompanied by blanching of the conjunctiva, complete whitening of the sclera and more or less pallor of the palpebral skin. The conjunctival vessels are reduced to microscopical threads and the superficial veins generally require a lens to locate them.

We are principally concerned in the *local* vessel-contractors which are chiefly cocaine, the majority of the cycloplegics, and the suprarenal extracts. The two first are fully discussed elsewhere; of the last named it may be said that Bates[35] drew our attention to the effects of an extract of suprarenal capsule upon the eye and showed that it acts as a powerful vaso-constrictor. Takamine, through Parke, Davis & Co., put at our disposal adrenalin hydrochloride, a much more convenient and cleanly preparation of the suprarenal body. One of the early preparations was the liquid extract of suprarenal glands made with glycerine, one part being equal to one part of the fresh gland. Since that time numerous substitutes for this useful agent have been marketed but it cannot be said that any of them is more valuable in eye surgery, although several are cheaper and probably of equal importance from the ophthalmic standpoint.

Besides adrenal, adrin, atrabilin, hemostatin, suprarenaline, adrenin, suprarenin (both animal and synthetic) we have hemisine, rena-

[35]Bates. *New York Medical Journal,* May 16, 1896.

glandin, adnephrin, paranephrin, renastyptin and a dozen other substitutes for adrenalin.

Most of them are, like the original adrenaline chloride, sold as 1:1,000 solutions with or without some preservative (chloretone, common salt, boric acid, phenol, etc.) and protected from light and air in glass-stoppered, amber bottles.

It is still believed by some surgeons that the vaso-constrictor qualities of suprarenal extract may be utilized in the treatment of external diseases of the eye. Such a position ignores the well-worn pathological idiom that local distress is the cry of the affected parts for blood. The continual hyperemia of the oculo-vascular system is merely nature's effort to meet germicidal and other hostile invasions of the eye-coverings by a free supply of blood. To arrest this flow of nutritive fluids is to postpone or prevent a cure of the disease. Yet as local hemostatics and as adjuncts to eucaine and cocaine (eucapren, cocarenaline, caprenaline), eserine, atropine, fluorescein, suprarenal derivatives have an important place in ophthalmic practice.

Sweat Bath. Hydrotherapy.

As a hint to the embryo ophthalmic surgeon I may say that I am in the habit of furnishing patients for home or hospital treatment with definite directions for giving this rather powerful adjunct to ophthalmic surgery. The directions are printed or written so that nothing is left to the imagination or memory of the patient or nurse. The baths should be given when the stomach is empty. The patient should be in bed and wrapped up to the chin in a woolen blanket and again covered with at least four woolen blankets. Under the latter six quart bottles containing boiling hot water should be placed. If used at all, pilocarpin or other adjuvant should now be given by the mouth or hypodermically. The patient is also given to drink at least a pint of very hot water, very hot and weak lemonade, or very hot tea, to be administered through a bent glass tube, while he is lying down. In a few minutes he should begin to break out in a profuse perspiration, which should continue for at least an hour, only stopping short of that time if he shows any bad symptoms. At the end of (one and a half or) two hours he should be thoroughly dried and the skin rubbed with alcohol and then allowed to rest for another two hours, when he may go out if he wishes.

Bier's Congestive Method. Hyperemia Treatment.

As an adjunct to surgical procedures this method has been of some value, but it seems likely to pass into the limbo of forgotten things because of difficulties of application and since we possess in *dionin* and other remedies more satisfactory agents. I have employed for the purposes of obtaining ocular hyperemia both the Pynchon pump and the Victor suction apparatus and believe it has a place in ocular treatment.

Hoppe[36] uses an apparatus that consists of a small glass cup, rubber bulb and manometer. Applied to the closed lids of a normal eye, a 30 mm. mercury pressure produces hyperemia and serous infiltration of the skin and tarsal conjunctiva, the lids becoming of a violent hue. The congestion is the result of venous obstruction. The reaction is more marked when the lids are away from the eyeball. Lachrymation then becomes more intense, the secretion being of a sero-muco-sanguinous nature. The contents of the Meibomian tubules and goblet cells may also be expelled, although the bulbar and episcleral veins show no changes.

The marks of congestion disappear after removing the instrument. Conjunctival and cutaneous hemorrhages may occur, but only after exposing the lids to higher pressures.

Thirty cases of ocular disease were studied under the influence of the congestion apparatus. Six were chronic and three acute cases of

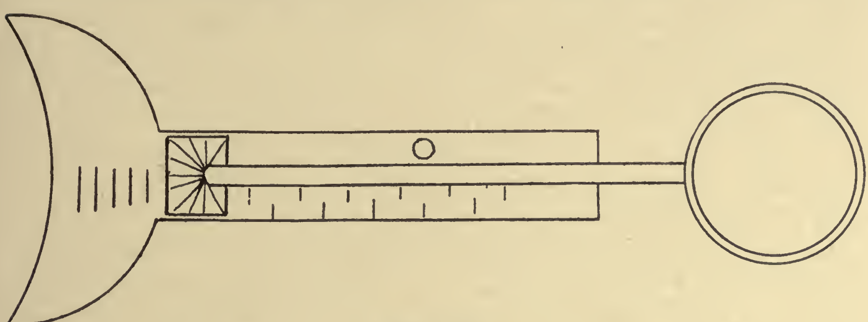

Fig. 149.
Kauffmann's Apparatus for Massage of the Eyeball.

purulent inflammation of the Meibomian glands, one chronic blepharo-conjunctival ulcer, one chronic hyperemia and thickening of the lid margin, two furuncles of the eyebrow, and one cold glandular abscess. The other cases included styes of various sizes and in various stages.

Treatment proved to be very satisfactory. Relief from pain was prompt, enabling the patient to attend to his occupation between treatments. Incipient inflammatory processes were checked, advanced conditions speedily regressed, often with the expulsion of a purulent core. Chalazia were less easily influenced by this treatment. Where pus had already formed he did not hesitate to make small incisions before applying the instrument.

Thirty to forty millimeter pressures applied fifteen to thirty minutes at a time, two or three times daily, usually suffice. This method, he contends, should not be considered the only form of treatment, but rather an additional remedy at our command; often used to best ad-

[36]From the abstract in the *Annals of Ophthalmology*, 1907.

vantage in conjunction with other therapeutic measures. The apparatus should always be used by the physician himself.

Kauffmann[37] utilizes a Kluge eye-cup by attaching to it a syringe (see figure) whereby the air in the tightly fitting cup may be exhausted or the pressure increased at will. Moreover, the cup may be filled with watery solution so as to combine the hyperemia treatment with the local effects of the liquid. The barrel of the syringe is marked off so that a record may be kept of the amount of force used at each treatment.

Phlebotomy. Venesection. General Blood-Letting.

In the revulsion of feeling and the reversal of public and professional opinion this method of lessening blood-pressure, removing the volume of toxic blood, reducing abnormal temperature and of relieving the pain and congestion of inflamed tissues has almost been forgotten. In my opinion, there is still a place for this remedy, especially in cases of acute iritis, acute inflammatory glaucoma, scleritis, threatened panophthalmitis occurring in robust, full-blooded individuals that were benefited by "letting blood" in the good, old way. Webster Fox has voiced this sentiment quite recently and the ophthalmologist would do well to bear it in mind.

From four to ten ounces of blood may be drawn from the upper arm and the venesection may be repeated if necessary.

It has been said that the American is not a fit subject for phlebotomy, and it is quite true that the systemic and local effects of this form of depletion may usually be reached by purgation, counter-irritants and such local lymphagogues as dionin, but there still remains a class of plethoric individuals in whom acute outbursts of inflammatory eye disease urgently call for more potent remedies.

Excepting in cases of extreme anemia, hemophilia, senile cachexia, Kyrieleis recommends venesection in relapsing ocular hemorrhages, and if not successful, as a last refuge, ligature of the common carotid. However, he believes venesection has advantages over ligature: under aseptic precautions it is a perfectly harmless procedure and it may be repeated without damage as often as required.

Serum Diagnosis and Serotherpathy in Ophthalmic Operations.

This is a subject which is partially treated elsewhere in this *System* and although it is quite directly connected with operations on the ocular apparatus, must still be allowed to pass with a mere mention. By far the most valuable work (in this country) on the subject has been recently done by John Weeks[38] and the reader is referred to his monograph for the latest information on this subject.

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[37]Kauffmann. Ueber die Anwendung einer Luft-und Wassermassage am Auge. *Wochenschr. f. Ther. u. Hygiene des Auges, Jahr*, 5, No. 22.

[38]Weeks. The Status of Vaccine Therapy in Ophthalmology. *Journ. Am. Med. Assn.*, July 23, 1910, p. 265.

It is quite possible that *many an infective process preceding, accompanying and following surgical operations on the eye would be much modified if the disease were properly attacked from this standpoint.* I would strongly advise the ophthalmic surgeon who wishes to go thoroughly into this matter to consult Chapter 10, page 183, of Wood's *System of Ophthalmic Therapeutics.* In it Dr. Irons has carefully considered the usual serum and bacterial remedies in both their diagnostic and therapeutic relations. It would, of course, be out of place to devote much space in this *System* to such a subject.

Artificial Eyes and Similar Devices. Protheses Oculares.

Although one generally thinks of an artificial eye as worn subsequent to an enucleation (or some substitute for that procedure) yet in my chapter on the Orbit a number of operations are described that have for their purpose the preparation of that cavity for the wearing of a prothesis. Apart from these latter interventions the subject is of considerable moment to the ophthalmic surgeon. For that reason and owing to the fact that some works on ophthalmic surgery give little or no attention to the better adjustment and care of artificial eyes is my justification for quoting rather largely from my contributions to the *System of Ophthalmic Therapeutics.*

In my judgment it is not correct practice to leave this work to the optician or to some jeweler who exposes a few artificial eyes for sale. The final success of an enucleation, bulbar evisceration or Mules' operation may easily depend upon the shape, size, adjustment and manner of wearing a prothesis—details that only an experienced or, at least, trained surgeon can superintend.

In the following pages I have considered the most important questions that arise in connection with this matter and for the rest I would refer the reader to Pansier's *Traité de l'oeil artificiel.* 1905, a most interesting little book that will fully repay perusal. This work appeared before Snellen's improved or solid eye was introduced to the profession and, of course, no notice has been taken in it of that excellent improvement on the older form of prothesis.[39] With that exception, the treatise is in every respect complete to the present date.

Historical.

Not only is it well established that the Egyptians, the Arabians and the early Greeks were acquainted with the fact that an artificial eye can be worn in place of one lost by accident, disease or operative measures, but it is also certain that the oculists of ancient times were generally in the habit of adjusting these cosmetic articles.

Ambrose Paré (1579) was the first to give a precise description of the

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[39]The derivation of this term is not as clear as most of our medical dictionaries would have us believe; it is probably not only a synonym but a contraction or corruption of *prosthesis;* a substitution or imitation.

artificial eye. His work is illustrated by several drawings of protheses that show both surfaces much like the shell eyes of our own time. He described these as made of metal, painted and enameled to imitate the human eye, Another variety, made of metal and painted leather, was edged with silk, to the outer border of which was attached a cord that passed under the hair and over the ear. By this means the eye could be removed from the orbit any time the wearer desired.

At the beginning of the 18th century artificial eyes began to be manufactured of glass. Heister, for example, in his *Institutiones Chirurgicæ*, 1750, devotes a whole chapter to the artificial eye.

Pansier[40] quotes the description given by a Nevers jeweler of his method of making (about 1750) artificial glass eyes. It does not much differ from the manufacture of shell eyes in our own day.

Most of the information regarding artificial eyes, as they were made and used about this time, is derived from the thesis of Muchart, Tübingen, 1749. From it we learn that there were at least two varieties worn in his day, *ecblephari*, kept in place by an iron circlet about the head, and *hypoblephari*, the ordinary shell-eye. A third class, the ancient variety, at that date rarely used, was the silver and gold eyes of the Egyptian and Arabian oculists, in more modern times painted or covered with colored enamel, to represent the iris and pupil.

Mauchart gives explicit and sensible directions regarding the care of the prothesis—how to put it in place, how and when to remove it, how to cleanse the conjunctival sac or orbit, and how and when to use detergent lotions of most value for the latter purpose. He gives the formulæ of these collyria; an important one being a warm mixture of rose water; another with "Eyebright"—all of them to be applied with a sponge. He fully recognizes the disadvantages as well as the advantages of the prothesis, the danger of irritation of the socket, as well as the possibilities of harm to the fellow eye.

For a long time Venice enjoyed a monopoly of the manufacture of glass eyes and the strictest laws were enforced to prevent the secrets of the trade from being carried abroad. Eventually, however, France, Bohemia and other countries became such rivals of the Venetian artists, that at the end of the 18th century the glass eyes of Murano no longer enjoyed their former commercial supremacy.

About this time Storck invented or discovered a successful method of manufacturing glass eyes and, finally, in 1818, Hazard-Mirault published his practical treatise on the artificial eye in which most of the details of manufacture, including the rules for closely imitating all the parts in the front of the human eye, are plainly set forth. After him (almost with him) came the two Desjardins and Boissonneau. The last named optician was among those who made Paris the headquarters for artificial eyes for the next half century.

The manufacture of enameled eyes was introduced into Germany by Ritterich in 1850. That country before very long displaced France in the output of artificial eyes and at length acquired possession of most of the foreign trade and has held it ever since.

Owing to the fragile character of enameled eyes, many substitutes have been proposed. These have been chiefly protheses of lead, aluminum, ivory, bone, caoutchouc, vulcanite and celluloid.

Nieden and van Duyse devised protheses of which the body is made of material not readily broken, with a superimposed enameled iris and cornea. The substitutes (of French manufacture) that I am best acquainted with, are made of celluloid, but although much cheaper than the enamel shell, are expected to last only a few months. Moreover, they lack the peculiar brilliancy of the enamel eye, their margins are thin and irritating, they readily corrode and lose their polish, and I

[40] Pansier. *Traité de l'oeil artificiel*, 1895, p. 17.

do not believe their single virtue—freedom from danger of breakage—compensates for these defects. On the other hand, protheses made by a competent workman, of enamel glass, resist the action of the tears and mucoid discharges from the conjunctival cavity, as well as damage from other sources of deterioration, for one or two years.

Practically the same remarks apply to all other substitutes for eyes made of enamel glass. With a large supply both of the irregularly ovoid Reform protheses, as well as of the older shell plates to choose from, not to speak of the possibility of securing the services of a competent artist to make and adjust artificial eyes to almost every unusual form of socket, no patient can complain that he cannot have a satisfactory companion for his remaining eye.

The Snellen and other Modern Forms of the Prothesis.

At the present day we in America are dependent almost entirely upon the output of German factories—especially those of Wiesbaden—for all forms of protheses. The exception is that a few American firms are beginning, with imported workmen, to furnish specially designed eyes to suit unusual sockets, as well as eyes specially painted and prepared to imitate exactly the fellow eye. The ordinary protheses, as generally employed, are the old shell-eyes very little changed or improved during the past 100 years, and the new *"Reform-Augen"* the larger, thicker, solid or hollow eyes introduced by Snellen. The latter have the advantage of filling more completely the conjunctival sac, of pushing forward the upper cul-de-sac and so removing the sunken appearance (less easily remedied by the shell-eye) at the superior margin of the orbit. The effect of the Snellen eye is to produce a better prothesis; in most cases the eye stands out well. One of the purposes, also, of the "Reform" eye is to render needless such operations as that of Mules, Fox and Lang—the introduction of sponge, gelatine, globes of glass, metal or other foreign substances into the vitreous or orbital cavity or Tenon's capsule for the purpose of forming a more prominent or a better stump for the superimposed artificial eye. There are cases, of course, in which even the thickest Snellen eye cannot take the place, in this respect, of some one of the above mentioned procedures but, on the other hand, a specially prepared "Reform Auge," suited to the case in hand, will go far to imitate the prominent globe or the receding orbital walls of the opposite eye.

Shells to Prevent Symblepharon.

Apart from the ordinary uses of the artificial eye it must not be forgotten that glass and porcelain shells are occasionally employed to good purpose to prevent symblepharon after wounds, burns and operations on the lids. These are of two kinds; one sort, almost exactly like

the artificial shell but adapted to the particular requirements of the case; a second variety, like the first, only pierced with a central aperture for the protection of the cornea, to permit the escape of secretions and to allow the entry of collyria to the globe and sac.

Composition of Artificial Eyes.

The protheses of the present day are made of enamel (a fusible, opaque mixture of silicon, potash, lead and tin) colored with various pigments; they are not prepared of ordinary glass, as was once the case.

The Functions and Advantages of the Artificial Eye.

Pansier[41] sets forth the advantages of the artificial eye from the social and commercial side. For the well-to-do it covers what would otherwise be a terrible disfigurement; for the poor man it also serves to conceal what would infallibly prevent him from obtaining most kinds of work, since nobody cares to engage an artisan who presents the appearance of having but one eye.

The functions it subserves from the medical side are several. (1) It regulates the movements of the lids. The upper lid deprived of its support by the loss of the eyeball, falls flat and flaccid; it sometimes turns in because the contracting marginal fibers of the orbicularis have nothing to oppose their action. (2) The artificial eye relieves the friction of the lashes upon the lining of the sac due to this form of entropion. (3) The artificial eye directs the drainage of the sac, especially of the tears. (4) It protects the wall of the cavity from infection and from foreign bodies. (5) When the prothesis is worn over a globe still sensitive to light-impressions, the artificial eye may serve to cut off the light rays that, in some instances, are a source of acute annoyance to the patient. (6) In children a large-sized, well-fitting eye is a necessary stimulant to the development of the orbit and face. Deprived of the globe the infantile orbital cavity on the affected side does not increase *pari passu* with its fellow. The prothesis prevents to a large extent this one-sided growth, provided, always, that the artificial eye is as large as possible and is almost constantly worn.

Practically, whenever an eye is removed its place may be taken by an artificial one. Pansier[42] ordered a prothesis for an infant 18 months old, and cases where they were worn at 2 and 3 years are not uncommon.

After an enucleation the *artificial eye may be fitted as soon as the wound of operation has fully cicatrized.* There can be no fixed rule, but the adaptation of the prothesis should not be deferred too long

[41]Pansier. *Loco. cit.*, p. 44.
[42]Pansier. *Loco. cit.*, p. 48.

or done too early. An average period of four weeks is about right, although Klaunig, Galezowski and others believe that 14 days is generally long enough to wait.

When adjustment of the artificial eye is too long delayed the lid tissues contract, the cul-de-sacs diminish in depth and there is some difficulty in adjusting an eye that is large enough, that is satisfactory to surgeon or patient or that, sometimes, is easy to retain in its proper place.

After exenteration of the orbit, especially if any portion of the lid tissues has been involved in the operation, it is extremely difficult to fit a prothesis that will produce a satisfactory cosmetic effect. Since the introduction of the Snellen eye and the possibility of having artificial eyes specially made and adjusted by competent artisans this difficulty has, in a measure, been overcome. Still, the adjustment of a prothesis after an extensive orbital exenteration remains very unsat-

Fig. 150.
Various Forms of Prothesis after Enucleation and Orbital Exenteration.

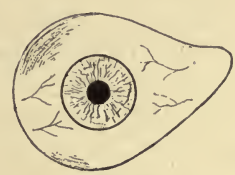

Fig. 151.
Artificial Shell Eye.

isfactory and many patients prefer to conceal the deformity with a skin-colored shade—preferably of celluloid—adjusted closely to the orbital margins, rather than wear an eye that fails to disguise the defect. This matter is fully considered elsewhere in this *System*; see the chapter on Enucleation and on Orbital Operations.

An artificial eye can generally be worn with satisfaction over an atrophic globe or over one from which the intraocular contents have been removed. When the cornea has been preserved it is well to order an eye whose margins mainly support the prothesis, thus preventing as far as possible undue pressure on the sensitive corneal surface. There are cases in which sympathetic irritation has appeared in the fellow eye—a condition commonly calling for complete enucleation. It is even possible that an ill-fitting, or even a properly adjusted, shell may light up a cyclitis in the underlying globe, an inflammation capable of transmission to the opposite eye.

Requirements of a Properly Adjusted Prothesis.

The artificial eye should exactly resemble the fellow in coloration of the sclera and iris, size of the cornea, tint of the sclera and medium dilation of the pupil; in the appearance of the anterior chamber, position of the visible blood vessels, location of the cornea, and convexity of the globe. Its size should conform as nearly as possible to the conjunctival cavity and orbit. In people with sensitive orbits I am in the habit of introducing at first an eye somewhat smaller than the one I expect them to wear finally. After an interval of a few weeks I adjust the permanent prothesis. If he can afford it, the patient ought to be supplied with at least two such protheses, in case one is lost or broken.

Artificial eyes should be perfectly polished, and without defects; especially should they be free of those pin-point airholes in the glaze one occasionally sees in the cheaper grades of protheses, since they are likely to harbor secretions that in a short time render the surface rough and irritant.

In passing, it may be noticed that worn, scratched or roughened artificial eyes may be polished and their life of usefulness extended, although the newly polished surface does not endure as long as the original glaze.

The edges of the prothesis ought not to be too thin—at least a millimetre thick—nor should the body of the eye be too delicate; it is then easily broken.

That the very particular patient may be prepared for most contingencies he should have two differently colored artificial eyes, one with a comparatively small pupil for use during the daytime, when he is exposed to a full illumination and the pupil of the healthy eye is somewhat contracted, and the other, with a larger pupil, for evening wear when the pupillary expansion of the seeing eye is greater than during the daytime.

Shape and Size of the Prothesis.

The artificial eye must necessarily be adapted to variations in the capacity, depth and height of the conjunctival cavity. As a rule, however, the cornea is placed below the horizontal line (because of the greater depth of the superior fornix and width of the upper lid) and towards the inner canthus, where the narrow part of the eye is adjusted. It thus follows that the right eye will not generally receive a prothesis intended for the left socket, and vice versa. This is, however, not always the case; indeed, Boissonneau sold an *oeil symétrique,"* to fit either side, but it was not a very satisfactory device.

Vendors of artificial eyes generally keep a few protheses on hand for such anomalies as symblepharon, partially obliterated or con-

tracted sulci, cicatricial deposits on the floor of the orbit, atrophic globes, etc., but the variations in these respects from the average socket are so numerous that it is generally difficult to secure an accurately fitting prothesis from even a large stock; it is much better to secure the services of a competent artisan, who will make a prothesis for the particular case.

Pansier's test of a properly adjusted artificial cornea is that when the patient fixes a point three metres distant the optic axes should both appear to cut that point. That is to say, for the distance there should be a slight, apparent convergence. Better a decided convergence than the slightest divergence. He also believes that the motility of the prothesis depends as much on the perfect adaptation of the lids and stump as to any other consideration. He prefers the Ferrall (Bonnet) method of leaving the musculature intact, a fact long ago observed by my confrère, Frank Allport, who sutures the tendons of the straight muscles at the medial incision, thus obtaining the fullest effect of their action on the ocular pad, whether it be that resulting from a Lang's operation, an abcission, or an ordinary enucleation.

Introduction of the Artificial Eye.

This is generally quite simple. Holding the small end of the prothesis between the thumb and finger of the right hand apply the thumb of the left hand to the eyebrow and raise the upper lid, at the same time asking the patient to look down. Introduce the larger end of the eye well into the upper sulcus. Remove the left thumb from the eyebrow. Rotate the prothesis on its axis so that the smaller end almost corresponds to the inner canthus. With the left forefinger draw down the lower lid; the artificial eye will slip into its place. Further adjust the prothesis by gently separating the two lids for a moment.

If the patient introduces his own eye he uses the left hand where the surgeon employs his right. As a matter of experience the patient soon learns not only to adjust but remove his own prothesis better than anyone can do it for him.

Removal of the Prothesis.

The majority of artificial eyes may be removed from the socket by drawing down the lower lid with the forefinger and at the same time pushing its point below the edge of the prothesis as it is felt beneath the lid-skin. The eye readily drops out over the margin of the lower lid. This manoeuver failing, draw down the lower lid, insert the head of a pin beneath the lower margin of the shell at the inner canthus of the eye, and slowly pass it along towards the middle of the shell; the prothesis will be readily drawn out over the edge of the lid.

The patient can easily be taught both procedures and instructed how to remove the prothesis over a cushion or other soft object, to avoid the danger of breakage.

Care of the Shell.

For the first week or two, or until the patient and his orbit have become accustomed to the presence of what is to some extent an irritating foreign body, the eye should be worn only for a few hours daily. At first it may be kept in place for an hour at a time, say, three times daily, after which it may be worn for longer periods until it is eventually retained all day.

The prothesis should be removed on retiring at night.

I have a number of patients who, for various reasons—generally cosmetic—wear their prothesis day and night, and I cannot see that

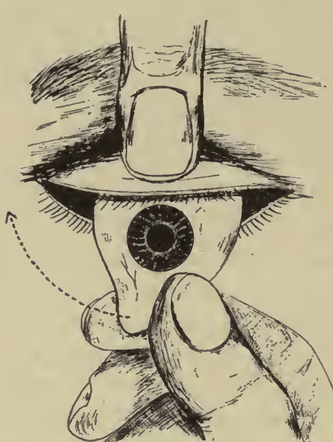

Fig. 152.
Introducing Artificial eye. (Left.)

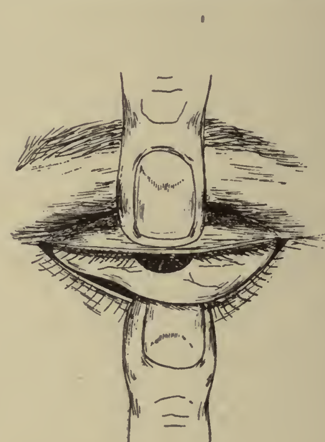

Fig. 153.
Removing Artificial Eye. (Left.)

any harm has arisen from following this plan, but, as a rule, the wearer should be told that it is conducive to the health of the parts to give the orbit a rest during the night.

After the removal of the shell at night the conjunctival sac should be washed out with a warm, saturated solution of boric acid, or with any other simple detergent wash, and the lid edges should be similarly cleansed.

When Should the Prothesis be Renewed?

The materials (enameled glass and glaze) from which the artificial shell is made, undergo chemical changes as the result of friction with the lid edges and exposure to the secretions from the conjunctiva. For this reason it is a mistake to add to these sources of deterioration by keeping the prothesis in solutions of any kind—even

water—over night. The eye should be cleansed with warm water in which a little baking soda has been dissolved, wiped perfectly dry with a soft, clean and old linen or cotton handkerchief or towel, polished and placed in a small box, to protect it from dust, until it is ready for use in the morning. Treated in this way it ought to last for one or two years. As soon as it loses its pristine polish, or sets up irritation about the orbit, or loses its motility, or looks as if it were too small or too large, it ought to be renewed. The most sensible thing for the patient to do is to return to the oculist every six months for the purpose of having his artificial eye and the socket critically examined; if any change is called for, the surgeon is more likely to perceive it.

Inconveniences and Dangers of the Artificial Eye.

Although, in most instances, the prothesis masks an evident defect, protects the socket and its lining, and insures proper drainage of the eye, there are some possibilities of danger that inhere in the wearing of the shell, especially if it is not carefully selected, properly adjusted and duly cared for.

The depression below the upper margin of the orbit (which is always more or less marked after enucleation or evisceration) is due chiefly to the contraction of the *levator palpebræ superioris* that in the absence of a globe of normal size pulls the upper edge of the tarsus (into which it is inserted) directly backwards instead of upwards over the eyeball, as it usually does. In his anxiety to correct this part of the deformity, the surgeon (more frequently the optician) may introduce too large a prothesis, especially if it be of the flat type of the artificial eye. This act results in the inordinate stretching of the parts, discomfort to the wearer and interference with the proper movement of the lids.

Several observers have recorded instances of damage to the socket and the remaining eye as the result of the introduction and attempted use of too large or an ill-fitting shell. Among these are sympathetic irritation, migratory ophthalmia, obliteration of the cul-de-sacs, atrophy of the lid muscles, abnormal stretching of the lid skin, symblepharon, chronic catarrh of the conjunctiva and epiphora.

If the depression caused by the action of the levators is not remedied by the artificial globe, there are several operations (those of Critchett and de Wecker, for example) to which one may have recourse, although it may be said, in passing, that the Snellen eye, as well as other specially constructed shells, have much reduced the proportion of these defects.

Obstacles to Wearing an Ocular Prothesis.

Most of these have already been mentioned, but it is as well to

repeat some of them. As a general rule, when the sac is for any reason too small to admit an artificial eye, it will require, and may, as a rule, have a satisfactory operation performed upon it.

Conjunctival bridles may be incised, and conjunctival symblepharon treated, while even total adherence of both lids and obliteration of the sac may be remedied in consequence chiefly of the labors of American surgeons—notably Weeks, Hotz, Wilder and Woodruff. See the chapter in this *System* by Beard.

In some cases the artificial eye, acting as a foreign body, sets up or perpetuates a previously existing conjunctivitis, or encourages exuberant granulations along the line of incision. Especially in the case of the shell eye, it may prolong an original vice of the conjunctiva by preventing the escape of secretions. This is especially true of that variety of artificial eye that has a rounded margin with an opening, however large, into the body of the prothesis. The concavity holds fluids that readily undergo decomposition. If the borders or surfaces have been eroded, or have lost their polish, this is all the more likely to happen. It is needless to point out that the eye should not be again worn until the disease has been cured, and that no prothesis should be kept in place that has not perfectly smooth surfaces throughout.

How to Order an Ocular Prothesis.

If the surgeon lives in the city and can send his patient directly to the optician, so that the coloration, prominence and other characteristics of the remaining eye may be noted and a selection of, say twenty protheses returned that a properly fitting shell may be chosen, it is, of course, the best plan to adopt; but if patient and surgeon reside at an inconvenient distance from the vendor of artificial eyes, some other course must be pursued. To meet this latter difficulty, numerous suggestions have been made and carried out—such as the preparation of models in wax, paraffin, soft tin, lead or aluminum; of or gutta percha softened in hot water, or carving them out of such materials as ivory, wood and bone. As for the coloration of the remaining eye it was either described or a painting of the eye in pastels or oils accompanied or formed part of the model; or a large photograph was taken of the eye, properly colored.

In addition, the diameter of the cornea, the length and height of interpalpebral space, the average width of the pupil, the coloration of the conjunctiva and the distribution of its vessels, the degree of bulbar prominence and other necessary details were written upon the photograph. As a matter of practice nowadays, most wholesale opticians issue blanks upon which the surgeon writes the information just referred to, as well as a record of other necessary details. On the ar-

rival of a selection of shells he proceeds to choose from the consignment and adjust a properly fitting eye.

OPERATIONS FOR THE CURE OF AMETROPIA.

A number of operations have been from time to time suggested for the *permanent cure of ametropia* mainly by altering the shape and size of the eyeball. We know that a change in this direction is brought about after cataract extraction, iridectomy, muscle operations, etc., and if similar procedures could, with any degree of certainty be made available for astigmatism, hyperopia, etc., there seems no just reason why it should not be generally adopted. I would, in this connection, call attention to L. Müller's operation suggested for the relief of excessive myopia. This method of reducing the antero-posterior diameter of the eye is described under operations for detached retina (q. v.).

Traction Flap for Myopic Astigmatism.—E. E. Maddox (p. c.)

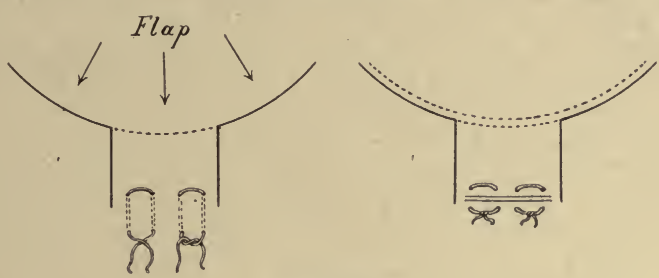

Fig. 154.

Sutures Inserted Into the Bridge of Conjunctiva in The Maddox Traction Flap Operation for Astigmatism. **Sutures Tied.**

describes an operation for myopic astigmatism. To flatten the cornea make a large cataract incision parallel with the least curved meridian of the cornea, continuing it into a broad conjunctival flap. Suture this flap with sufficient traction thereon to flatten the cornea. After inserting the median suture final reposition of the iris should be effected if necessary, before putting in the lateral sutures.

After a few weeks repeat the same procedure on the opposite side of the cornea. For slight degrees sufficient results may be obtained by withdrawal of the knife before division of the conjunctival flap, leaving the bridge, and taking care to put a bandage on the eye in such a way as to obtain that overriding of the flap which we seek to avoid after cataract extraction. A better plan, however, is to shorten the bridge after the manner of a tendon tucking operation by sutures, sufficiently explained in the accompanying diagram. See Fig. 154.

These operations are not to be advised unless under extremely ex-

ceptional circumstances as when, for example, a single eye throws its possessor out of some important employment, because he cannot quite reach the visual standard required. In some cases a single operation will suffice to give the necessary improvement.

Maddox further says: "For *short sight* of low degree I have once only operated, making one broad sutured incision upwards and another, at a different date, outwards. The patient, whose whole future depended on the result, as well as the means of a widowed mother (without which incentive I would not have operated) passed his tests into the Royal Engineers after having been previously twice rejected. I have declined to do this operation on others since, not having met a case in which the importance was of sufficient magnitude to justify any operation so much invading the interior of the eye. I should be sorry to introduce this as a regular operation, though it answered its purpose in the first and only case. The operative defect was noted by the examiners. The case was reported in the *British Medical Journal*, 1905, Oct. 21. So great was his importunity, that after having the risks fully set before him, he was quite prepared to lose his eye rather than give up all chance of passing, and would accept no refusal. I, therefore, look upon this as an isolated and exceptional case and not as a precedent for others."

Tattooing.

Although this subject is more fully and properly treated in Oliver's chapter, I wish to add that I have for a long time followed Webster Fox's* procedure in this minor surgical procedure.

After covering the leucoma with ink paste, the consistence of which is such that it does not run over the eyeball, he, with a piece of absorbent cotton removes the excess of ink over the tatooed spot. He does this for a double purpose, first, to see whether he has covered the whole of the leucoma, and, second, to see how much ink the needle points have carried into the tissue. He sometimes, if the needles do not puncture deep enough, scarifies the tissue with the point of a Beer's knife. He again applies the ink paste and rounds out the edges of the leucoma. An important part of the process now follows.

The eyeball is exposed to the atmosphere and were this exposure continued for some time the ink on the cornea would cake and become hard. He, with a piece of absorbent cotton, dries the eyeball of any lachrymal secretions, never touching the cornea, however. Then *he fans the eyeball rapidly*, which in a few moments dries the ink sufficiently to hold it in place, and again looks to see whether any tears have gathered in the orbital sac; if so, he drains them off with cotton, removes the ophthalmostat, closes the eyelids and keeps them bandaged for twenty-four hours.

*Fox. Tattooing of the Cornea. *Am. Med.-Surg. Bull.* Aug. 1, 1896.

CHAPTER VII.

THE INSTRUMENTS USED IN OPHTHALMIC SURGERY.

By PAUL GUILFORD, M. D., Chicago, Ill.

Classification of Instruments—Ophthalmic Instruments with Straight and Slender Handles—Scalpels—Bistouries—Lachrymal Knives—Keratomes—Cystotomes—Knife-Needles—Special Capsulotomes—Tattooing and Other Needles Mounted on Straight Handles—Knives Used in Cataract Extraction—Ophthalmic Instruments with Large or Crooked Handles—Ophthalmic Instruments with Double or Special Handles—Forceps-Scissors—Scissors-Handled Punches—Forceps—Scissors-Handled Forceps—Chalazion Forceps—Scissors—Ophthalmic Instruments and Appliances Without Definite Handles—Lid Specula—Lid Clamps—Syringes—Cautery Appliances—Irrigators—Canaliculus and Lachrymal Duct Probes and Dilators—Styles and Canulæ — Repositors—Spoons—Loops—Hooks—Spuds—Retractors—Needle Holders—Trachoma Forceps—Miscellaneous Instruments—Testing the Sharpness of Instruments.

As every ophthalmologist who has made a study of this subject is well aware, it is practically impossible to make even a list of, much less to picture and describe, *all* the instruments (with their innumerable modifications) that have in modern times been employed in ophthalmic operations. However, it is my purpose to classify and, so far as possible, mention the chief surgical appliances that are now used by the various schools of ophthalmic surgery in this and other countries.

It may at the outset be claimed that the *simpler an instrument the greater value it has.* The truth of this axiom is evidenced by the fact that only instruments of simple construction survive; complicated devices are generally consigned to the limbo of forgotten things shortly after their invention, if for no other reason than that the difficulties of asepsis, drying, polishing and repairing and, perhaps, sharpening, are so great that it is very difficult to use them for any length of time. Possibly another reason is that the inventions and discoveries of the embryo operator generally run towards complicated apparatus; it is rarely that the young surgeon invents a simple instrument. For this reason, if for no other, slight variations from well known models seem hardly worth mentioning even in a complete treatise on the subject;

hence, I have purposely omitted references to a large number of devices that are but slender variants of some previously invented instruments.

The illustrations are, as a rule, confined to the *essential parts* of instruments, that are commonly given in their natural size. The handles of knives and other cutting instruments are generally not portrayed as they are usually (or should be) of the same length.

In the preparation of this chapter I wish, at the outset, to acknowledge the assistance afforded me by Landolt,[1] whose writings on the subject form a classical introduction to the study of ophthalmic instrumentation.

I believe it would be well if the student of ophthalmic operations were to learn by heart the following observations made by him on the manipulation of instruments in general. The young surgeon will also find additional and more complete and illustrated remarks on this extremely important subject in the chapter by Bulson.

"In order to attain to the *requisite lightness and delicacy of handling,* we must bring our finger tips as close as possible to that portion of the instrument which is to perform the actual work—let us call it the "active part" of the instrument—because the tips of the fingers possess the most accurate tactile sensation.

"The *requisite movement* should be obtained from the finger-joints and not from the wrist, and even less from the arm. These two essentials will be obvious if we consider the execution of an exact drawing of small dimensions.

"To obtain the *requisite lightness and delicacy of touch* we must use the minimum of muscular effort in working with our instruments. A heavy or slippery handle, a forceps with a too resistant spring, etc., require a force which naturally detracts from the fineness of the execution.

"Resting the little finger on the orbital margin of the patient *gives a support to the hand* which will make the movements of the fingers steadier and more precise, just as the draughtsman supports his hand with the little finger on the paper. Still more important, this procedure ensures that the operator's hand moves with the patient's head, and any sudden movement on the part of the patient is thus discounted. If the hand of the operator is independent of the patient's head, it might happen that the patient would injure his eye against the instrument."

Landolt recognizes in all surgical instruments three portions—the *handle,* the *active extremity* and the intervening part, or, *shaft.*

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[1]Landolt. On the Form and Manipulation of Instruments Used in Ophthalmic Surgery. *British Med. Journ.*, Nov. 2, 1907.

Classification of Instruments.

It seems almost as difficult to classify as it is to enumerate the large variety of small appliances employed in eye surgery. Although it may with justice be said that even the best classification is none too good, one cannot avoid the conclusions of Landolt that the *handle* is the most important of all the parts common to ophthalmic instruments. I believe that a rational classification might be based upon the variations in that essential part of eye instruments. "It seems," says Landolt, "sometimes that the *importance of the handle of instruments* for our delicate operations has not been sufficiently appreciated. We may consider it from the point of *material, form, dimensions, weight* and *surface.* The handles of the instruments were formerly all of ivory.

Ivory is an ideal material for this use; it is not too heavy or too light, it is a poor conductor of heat, but its best quality is the character of its surface—it is not slippery, and yet adheres delicately to the fingers. We are thus able to manipulate the instrument with accuracy and lightness as well as security.

But we have been educated in the science of asepsis, and the sterility of our instruments must be our first consideration. There is no doubt that the ivory handles, as the makers give them to us, do not bear well the high temperature required for sterilization. But in reality it is less the ivory, than the cement and resin which are used in fastening the blade to the handle, that give way under high temperature. The resin melts and the blade soon hangs loosely in the handle. If, however, we can discover a cement which is not spoiled by heat, or if the maker will take the trouble to fasten the blade with a screw in a metal matrix made secure in the handle, this invaluable material may still be made use of. Although ivory cracks and is spoiled after repeated exposure to 140 degrees C., it is able to stand several sterilizations, and the handle can then be changed, as ivory is not an expensive material.

Instead of trying to save ivory for us, the makers of instruments have substituted for it iron, steel, and aluminum. Our brothers in general surgery have accepted this change without a murmur. Of course, when the instrument is held by the whole hand, the material makes little difference, but with us, who must manipulate our instruments with lightness, the weight and surface of the handle is of capital importance.

The handles of steel and iron are too heavy for our work, even the hollow ones as they are furnished; their weight and slippery surface makes us grip them with so much muscular effort that the delicacy of our manipulation suffers. The rough surfaces, although they are to be preferred to smooth ground surfaces, are not satisfactory. The

ideal material is still ivory, and the only thing which approaches it is aluminum.

Aluminum has another quality in which it approaches ivory, that is, lightness; it is superior to ivory in the ease with which it stands dry sterilization. Aluminum, however, at least that which our instrument makers use, is not always pure and is spoiled by certain antiseptic solutions; but this is of no importance, as dry heat sterilization is to be preferred to boiling, and simple sterilized saline solution to so-called antiseptic solutions during the operation.

There is little or nothing to say against the *form* of the handles supplied to us by the best makers. The handle thickens a little in its third part nearest the blade, a section of it showing a rectangle with bevelled edges. The surface of the cataract knife blade, as the iridectomy knife blade, is parallel to the broad side of this rectangle. This is quite correct. Though we hold these instruments in a different fashion, one must always have the tip of the thumb on one side of the broad surfaces and the tips of the first and middle fingers on the opposing broad surface of the handle, so as to prevent its rotating on its axis without the operator's wish. If, on the other hand, he desires to rotate slightly the instrument, he must be able to do so easily; this the bevelled edges permit. The corners must therefore not be sharp but rounded somewhat, so that the movements can be made slowly and precisely.

It sometimes happens that the blades of curettes and vectes are placed perpendicularly to the broad side of the handle, instead of being parallel to it. This is an unpardonable fault.

It is natural that instruments which are rotated around their axes while in use should have a handle a section of which is square, with rounded rather than bevelled edges."

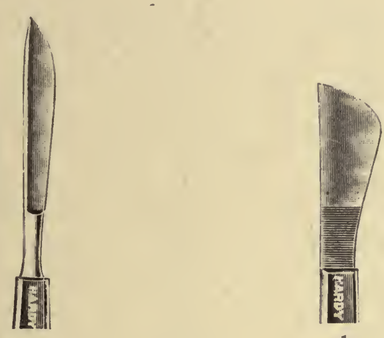
Acting, then, upon the hint given by Landolt, I propose to divide ophthalmic instruments into the following categories: *(a)*, instruments with straight, slender handles; *(b)*, instruments with large or crooked handles; *(c)*, instruments with double or special handles; *(d)*, instruments and appliances without handles.

A.—OPHTHALMIC INSTRUMENTS WITH STRAIGHT AND SLENDER HANDLES.

This class includes knives of various descriptions, scalpels, bistouries, all sorts of cataract and lachrymal knives, keratomes, cystotomes, knife-needles, tattooing needles and other needles mounted on handles, hooks, spuds, retractors, loops, spoons, repositors, sounds, canaliculus and lachrymal duct dilators, etc.

If it were possible it would be of great advantage to the oculist

if the straight handles of all the instruments just mentioned, could be made of the same length. Landolt particularly draws attention to the extreme length of the handles of some instruments. When it is remembered that the manipulation of these instruments should be carried on almost entirely with the fingers, as mentioned above and as Bulson describes in his chapter, it will readily be seen that there is no sense in having them as long as they are usually made. For example, Landolt draws our attention to the difference in this respect between the shaft of the Lüer model of Taylor's scoop and the Pagenstecher spoon. He remarks their extreme length and asks "how is it possible to execute satisfactorily with such instruments those most difficult of eye operations, the extraction of a dislocated lens, or of a lens in its capsule? It removes the operator's fingers to too great a distance from the patient's eye, and also from the *active* end. In order to



a b

Fig. 155.
Scalpels. a. Arlt's (large), b. Beard's (extra convex).

remedy this inconvenience, one is tempted to hold the instrument by the shaft only, and run the risk of its thin, round shaft revolving in the grasp, and further of destroying the proper balance of the instrument. The same is true of cystotomes, curettes, and spatulæ—in fact, of all the instruments which we introduce into the globe. Let us curtail the shaft of all these instruments to its proper length."

Scalpels.

These instruments must be small as compared with the scalpel of the general surgeon, but they should be strong, with a blade from 3 to 4 centimeters long. The Arlt model with center point and the Beard knife with a blade of great convexity mark the extremes in the shape of the blade.

C. H. Beard (*Ophthalmic Record,* Jan., 1905, p. 6) describes a slight modification of his own scalpel introduced ten or twelve years

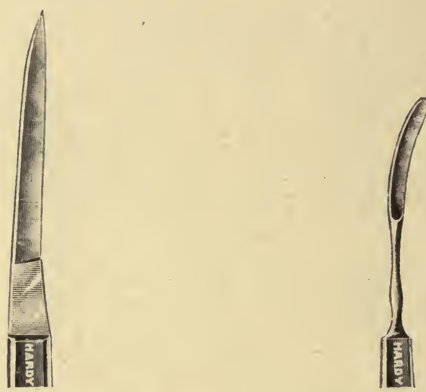
before. The difference lies in the greater convexity of that part of the edge which is situated near the extremity of the blade.

G. M. Black's pterygium knife closely resembles the Agnew iridectomy knife, but is one-third smaller. (See the *Ophthalmic Record,* Dec., 1897, p. 650.)

H. B. Young (A New Pterygium Knife, *Ophthalmic Record,* March, 1908, p. 133) has invented right and left knives, the blades being ground into a kidney, or pointless-sickle shape, sharp all around. The short, broad, pointless angular blade allows one to follow perfectly the contour of the globe.

Bistouries.

For deep incisions the blade should be straight and narrow and set firmly into the handle. For enlarging a fistulous tract the curved blade is the best.



a b

Fig. 156.
Bistouries. a. sharp straight, b. blunt curved.

Lachrymal Knives.

Among the innumerable canaliculus and nasal duct knives, the models of Weber, Bowman, Stilling, Agnew, Noyes and Schmidt-Rimpler are probably the most widely known.

C. R. Agnew (A Curved Knife for Stricture of the Inferior Lachrymal Canaliculus, *Trans. Am. Oph. Soc.,* 1878, p. 510) devised an instrument shaped somewhat like a strabismus hook, only a little more curved, and upon a smaller arc. The inside of the curved portion is sharpened and the extremity probe-pointed.

Keratomes.

This is the instrument of choice for all linear corneal incisions where a limited opening is required. The blade is practically a triangle, the length of each cutting edge being slightly greater than the base.

Cystotomes.

While the von Graefe model has had many modifications it has not been much improved upon. Models by Knapp, Landolt, Beard, Hay, Wilder and other surgeons are depicted in the text. See, also the chapter on the Extraction of Senile Cataract.

As Beard (*Ophthalmic Surgery,* pp. 66, 67) has properly said, "The instruments in the market are mostly modifications of von Graefe's. The outline of the blade is very suggestive of the side view of a goose's head. It will be observed that the back of the head of the goose is well rounded, and that the throat, from beak to neck, is a slight concavity. Now, what passes in this country as the Graefe cystotome is commonly an ugly, angular affair, something like that

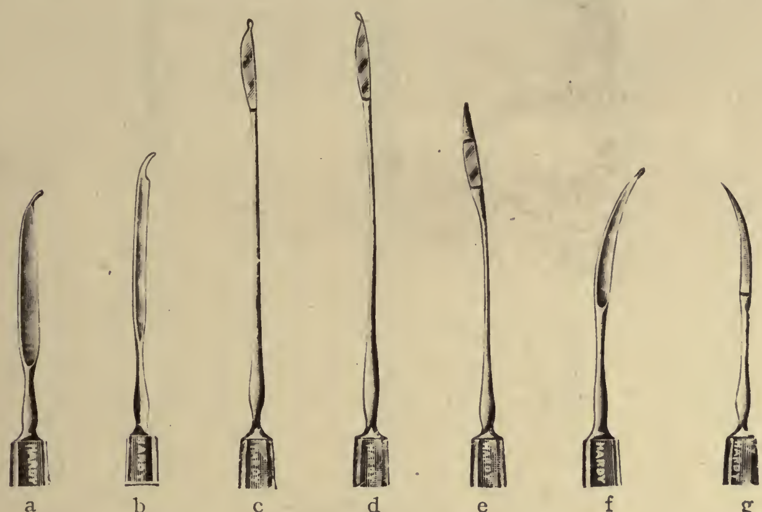


Fig. 157.

Lachrymal Knives. a. Weber's, b. Weber's canaliculus, c. Agnew's stricture (straight probe end), d. Agnew's stricture (curved probe end), e. Thomas' stricture, f. Weber's, g. Bowman's sharp point canaliculus.

shown in Fig. 159, 2e, being a mere spike, or peg. The back of the head is a right angle that catches in the incision and in the iris; and the throat is another angle in which rust and bacteria can accumulate. The idea seems to prevail that only a scratching point is required in a cystotome—that a cutting edge is a superfluity; and, doubtless, many a bungling capsulotomy is the result. A mere point does not *cut,* it simply *tears.* The point punctures the anterior capsule, and, unless there is an edge, and a sharp one at that, to make an incision, the alleged capsulotomy is nothing but an indiscriminate laceration. Knapp's cystotome is an example of an incisive one, but it, too, is objectionable by reason of its angularity. Someone has given to the

Graefe cystotome a small cutting extension backward which adds to its efficiency. The author has used for the past ten years a cystotome on the Graefe principle, only the head of the goose is larger, and the trenchant part is prolonged a little way into the neck (Fig. 159, 3e). Continuing the simile, the tip of the beak is on a lower level than the

Fig. 158.
Keratomes. a. Angular, b. Landolt's, c. Coccius'.

top of the head. In other words, the back of the blade is a parabola. This disposition of the point makes it easier to introduce and to push beneath the iris than if it were on a level, as is the Graefe cystotome, or actually in advance of the rest of the blade, as in the

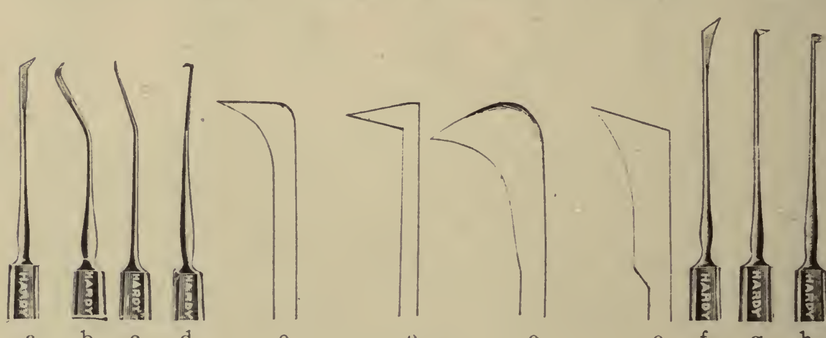


Fig. 159.
Cystotomes. a. Neuter, b. Schweigger's, c. Graefe's (back view), d. Graefe's (side view), e. e. e. e. Various enlarged outline forms of cystotomes, f. Knapp's, g. Graefe's, h. Beard's.

Knapp (Fig. 159, f). From the back of the head to the tip of the beak is 2 mm. The center of the crescent that constitutes the blade is 1 mm. wide, or even 1½ mm. The shank measures 22 to 25 mm. The

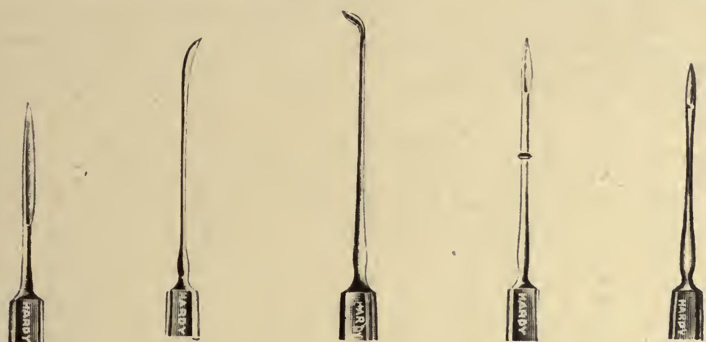
objects in having it larger than the Graefe are to make of it a cutting instrument of greater significance, thereby enhancing the precision with which it can be guided and inspected, and, in a measure, to forestall the ravages of those who afterward put it in order."

Landolt's flexible cystotome is in the form of a small, sharp sickle-shaped knife.

G. Hays proposed a shape such as would be obtained by first lengthening to the extent of four lines the stem of the ordinary straight instrument, and then by bending the lengthened stem at right angles to itself, at a point four lines distant from its toothed extremity, this extremity being moved in a direction the opposite of that in which the tooth projects (*Trans. Am. Oph. Soc.*, 1868, p. 62).

Knife-Needles.

In performing the operation of discission the models of Knapp,



a b c d e

Fig. 160.

Knife-Needles. a. Pagenstecher's, b. Sichel's, c. Jobson's iridotomy, d. Knapp's (with stop), e. Knapp's.

Hays and Ziegler are each excellent. The chapter on Discission of Cataract deals with the choice of these instruments.

G. B. Jobson, Jr., and H. P. Hammond have invented an iridotomy knife (*The Ophthalmic Record*, Sept., 1908, p. 448) which is similar to a cystotome with a large blade set at an angle to the shaft. The blade is made very thin, and broad and sharp-pointed, and is as long as the distance from the posterior surface of the cornea to the iris will permit.

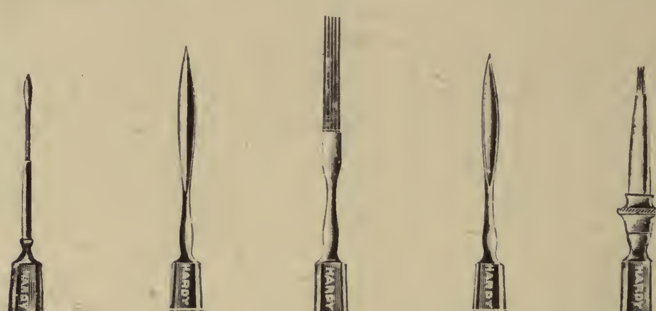
A. J. Erwin suggests a knife for secondary cataract that is about the size of the smallest discission needle, curved about 50 degrees on both the edge and the flat, with both edges and point sharp. Its action is corkscrew-like; by a rotary motion one may tear the capsule or draw it to the corneal margin and extract it. (*Trans. Section of Oph. A. M. A.*, 1896, p. 112.)

A. G. Heyl's discission needle is bent at an angle of 15°; it is 11 mm. long and 5 mm. broad. (*Am. Jour. Med. Sciences*, Aug. 6th, 1885.)

C. Pascheff (*Ophthalmic Review*, March, 1905, p. 70) describes his iridotome which consists of two lancets gliding one within the other. One terminates with a kind of cutting hook, which is intended to go below the iris; the second ends with a blade destined to cut through the part of the iris included between the two.

M. H. Post (Knife for Dividing Obstructing Pupil Membranes, *Amer. Jour. of Oph.*, May, 1908, p. 129) describes an instrument, whose blade, 6 mm. long and 1¼ mm. wide at its widest part, about 3 mm. from the point, has its back straight and dull, and a sharply-rounded cutting edge extending its entire length. The shank is cylindrical and of a diameter sufficient to prevent the escape of aqueous during operation.

John E. Weeks has invented a discission knife, a curved knife-needle, shaped something like a sickle. A hooked extremity is formed by a curve which extends from the middle of the blade to the point.



a b c d e

Fig. 161.

Tattooing and Other Needles Mounted on Straight Handles. a. Bowman's stop, b. Grooved discission (back view), c. Tattooing (flat form), d. Grooved discission (front view), e. Tattooing (round form).

The blade is about ⅔ mm. in width, and the shaft is just large enough to fill the opening made by the blade when the knife is properly entered. The concave edge and the point of the blade are rendered as sharp as possible; the convex edge of the point, for one millimeter up, is also sharpened. (*Trans. Am. Oph. Soc.*, 1895, p. 398.)

F. Buller's double needle to facilitate discission operation consists of two needles, 0.25 mm. in diameter and very sharp, placed exactly parallel in one handle. Their object is to transfix and steady the dense capsule while the discission is performed with the knife needle. (*Trans. Amer. Oph. Soc.*, 1899, p. 563.)

Special Capsulotomes.

R. Denig's capsulotome *(The Ophthalmic Record,* March, 1907, p. 128) when closed looks like a keratome; open it shows two blades with wide ridges on the inner side of each blade. It acts on the principle of a punch.

Frederick Tooke has invented a new forceps for the removal of the anterior lens capsule (*The Oph. Record,* May, 1910, p. 233). The blades, welded to the handles at an angle of 120°, are curved concavely below, which permits a uniform pressure over the whole of the lens surface. At the toe and heel of these blades two sets of tiny interlocking teeth are set which allow the operator to obtain a free hold of the underlying capsule.

In H. Culbertson's iricystome (*Am. Jour. of Oph.,* Oct., 1884, p. 202) the body of the instrument is on the principle of the Sands' needle-holder, the blades of which are flattened and spring apart when at rest. The front blade is solid, the back blade a little larger and fenestrated so as to cut out two sides of a triangle of the membrane. As the base of the triangle does not cut a primary incision is necessary.

Tattooing and Other Needles Mounted on Straight Handles.

While de Wecker perfected the operation of tattooage of the cornea, Bader, Agnew, Tyson and Schoeler also contributed instruments for the same operation.

Among the other needles mounted on handles we have Bowman's stop needle, Desmarres' paracentesis needle, Walton's grooved needle for soft cataract, Beer's cataract needle; and many others that are either shown as cuts or briefly described here and elsewhere in this *System.*

Wm. Thomson's tattooing instrument consisted of a small steel pen known as the lithographic crow quill, which had its point converted into a cutting surface. Its barrel held sufficient ink to complete the operation, and the pen was held with its trough uppermost. It was made to penetrate the laminæ of the cornea obliquely and by a slight lifting movement on withdrawal, a portion of ink was carried into each incision. (*Trans. Am. Oph. Soc.,* 1873, p. 86.)

Knives Used in Cataract Extraction.

The most important of these is, of course, the well known Graefe knife. It is made in all shapes and sizes and its modifications are so many that they equal in number almost every well known operator since Graefe's time. Whether made short or long, broad or narrow, the point and edge should be faultless. This knife is an exceedingly delicate instrument and so easily blunted as to be a source of anxiety

to the surgeon and his assistants from the time it is taken out of its box or tray until the operation for which it is used is concluded. The operating-room nurse should especially be warned against allowing any part of its point or edge to touch any object that is likely to dull it. Every surgeon should, of course, have a sufficient supply of these knives against emergencies. Preparatory to an extraction or iridectomy several of them should be in readiness for the operation.

It is difficult to say where or by whom the best knives are now made, but there can be be no hesitation in saying that the best are none too good. An average knife is 3.5 cm. long and 2 mm. wide at its base, where it should be fully ½ mm. thick. From the base to

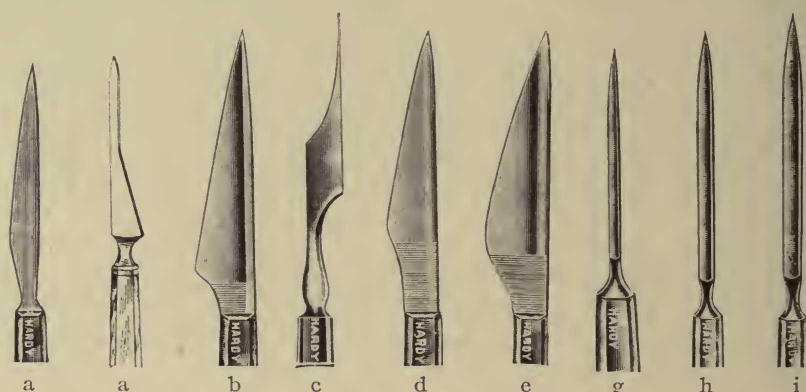


Fig. 162.

Knives Used in Cataract Extraction. a. Jackson's, b. Richter's, c. Inouye's, d. Beer's, e. Dixon's, g. h. i. Von Graefe's.

the point the thickness should decrease very gradually; 5 mm. from the point it should not be more than 1.5 mm. wide. Hence the outlines converge in a uniform curve to form the point. The latter should be needle-like and the whole instrument should be firmly and strongly made.

H. D. Noyes' cataract knife (*Trans. Am. Oph. Soc.*, 1869, p. 58) has a straight back and convex cutting edge for one-half the distance from the point. The convexity is the arc of a circle having a radius of four inches. In the posterior half of the blade the front and back are parallel, and the width is three millimeters. This maximum width is not attained until sixteen millimeters from the point. The total length of the cutting edge is thirty millimeters. The blade is very thin, is double-edged for some distance from the point, which is extremely sharp.

Edward Jackson's cataract knife (*Trans. Am. Oph. Soc.*. 1888, p. 62) is substantially a combination of the Graefe and Beer knives. The

blade consists of two parts, one beginning at the point and extending about 14 mm. like an ordinary Graefe knife, with a slender point, and becoming about 2 mm. wide, where it joins the other portion; the other spreading by the addition of a triangular piece of metal to the back, the cutting edge forming a continuous straight line with the edge of the first part, until 28 mm. back from the point the total width of the blade is 6 mm.

Later (*Trans. Am. Oph. Soc.*, 1900, p. 145) he modified the instrument so that the length of the blade is about 25 mm. and the maximum width is reached 20 mm. from the point. At 10 mm. from the point fully two-thirds of this maximum width is reached. From the point to the 10 mm. line the edge of the knife is straight. From the 10 mm. line it begins to curve, so that at the 20 mm. line the edge is parallel to the back. The back is straight throughout. The blade is flat and thin.

Melville Black's new cataract knife (*Ophthalmic Record*, 1904, p. 52) is fashioned exactly after the Graefe knife, except that it has a probe point for enlarging the primary incision or for completing the section when the knife is accidentally entered upside down.

J. H. Claiborne's lance-shaped cataract knife (*Trans. Am. Oph. Soc.*, 1908, p. 618) is a modification of the regular lance-shaped keratome, with a base of 14 mm. and a length up to the base line of 10 mm. For a description of the use of these cataract knives see the chapter on the Extraction of Senile Cataract.

A. Critchett's cataract knife (*Trans. Oph. Soc. United Kingdom*, 1888, p. 322), a modified Graefe knife, bulges immediately below the point. The blade is somewhat broader than usual and is made like that of a Beer's knife so that the aqueous may not escape too readily.

Canaliculus and Lachrymal Duct Probes and Dilators.

When gradual dilatation is desired the Bowman probes, in series, are the standard. Other favorite models are those of Theobald, Williams, Ziegler, Galezowski and Wilder, some of them being devised for the purpose of rapidly dilating the naso-lachrymal canals.

A modification of the Bowman probes are those invented by Henry W. Williams (*Trans. Amer. Oph. Soc.*, 1867, p. 30). They are flexible, that they may adapt themselves to the sinuosities of the lachrymal canal. These modified probes have bulbous extremities, of the sizes of Bowman's series, but are slender for one-third of the distance from the bulb to the flat disk at their middle. They are of alloyed silver to give an elastic flexibility; pure silver is too liable to bend.

Samuel Theobald devised probes that differ from the Weber

conical probe in that they increase in size more rapidly from the point backwards.

He later substituted aluminum for silver in the sizes above No. 7. Below No. 7 coin silver answers better. The aluminum was found

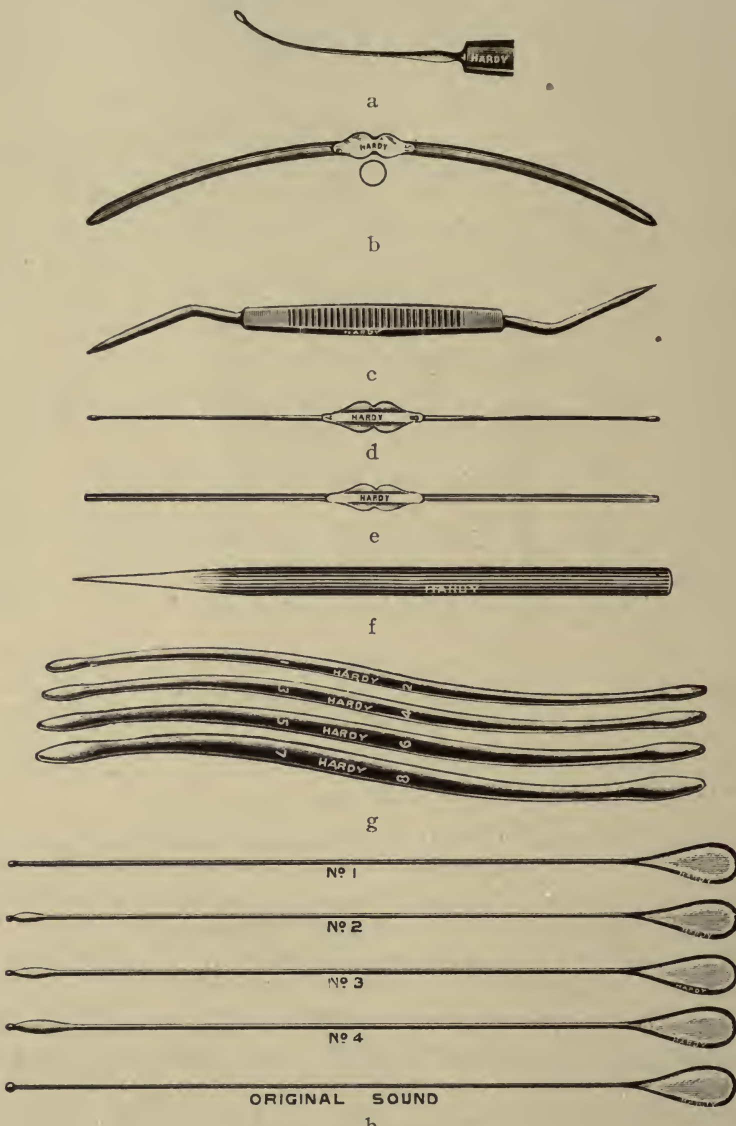


Fig. 163.

Canaliculus and Lachrymal Duct Probes and Dilators. a. Knapp's (fine silver), b. Theobald's, c. Ziegler's, d. Williams', e. Bowman's, f. Nettleship's, g. Couper's set, h. Beard's gold sounds.

to be smoother and more slippery and could be introduced with greater ease. (See the *Am. Jour. of Oph.*, March, 1887, p. 63; and *Trans. Am. Oph. Soc.*, 1901, p. 398.)

J. Oscroft Tansley's lachrymal probe (*Trans. Am. Oph. Soc.*, 1888, p. 63) is a modification of Weber's and consists simply in supplementing its size with one embodying the idea of Theobald of more thorough dilation of the canal. It is made of the same shape as the Weber probe and has the following scale: from No. 8 to No. 11 at the small end, and from No. 10 to No. 13 at the larger end.

He also describes in the same article three canulæ of different sizes, closed at their extremities with a solid bulbous point having the shape of Theobald's probes. Just above the bulbous point the canula is pierced by a number of small holes passing directly through to admit of their being cleansed easily. Fitted to a lachrymal syringe or rubber

a b

Fig. 164.

Repositors. a. Tortoise shell, b. Silver.

bulb the liquid passes laterally out of the small perforations. The bulbous extremities should be considerably larger than the canula.

J. J. Kyle (*Am. Jour. of Oph.*, Vol. 13, p. 362) suggests that the ordinary probe be made in halves with a screw joint so that one-half may be removed, while the other half, in situ, acts as a style.

Maynard G. Dorell's nasal duct dilator (*Trans. Oph. Soc., United Kingdom*, 1900, p. 275) when closed is only a little larger than a No. 2 Bowman probe; the maximum dilation of the terminal portion is equal to a No. 7. By turning the thumb-screw at the end of the instrument an inner rod is pulled through a steel tube and the probe point separated from the split extremity. A series of fine lines on the rod indicates the amount of dilation.

C. H. Beard (*Amer. Jour. of Ophthal.*, Oct., 1901, p. 290) has devised a series of gold sounds, made in different sizes of gold wire, with bulb or fusiform terminals, and with broad flat handles.

Styles and Canulae.

While these instruments or appliances are intended to dilate and keep patulous the lachrymal canal, according to this classification they cannot properly be placed with the lachrymal dilators in Class A. Chief among the canulæ are the models of Walmsley, Prince, Bowman, Fox and others.

Tansley (*loco cit.*) also describes a lachrymal style—a silver tube, the upper part of which is bent at right angles, cut away in a manner

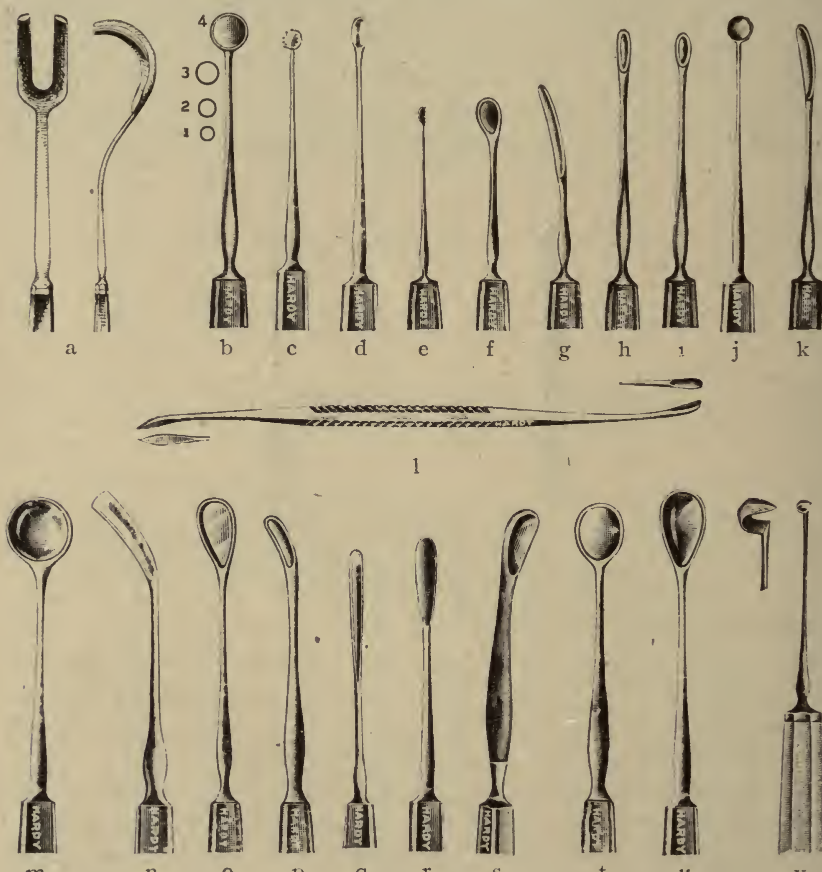


Fig 165.

Various Ophthalmic Instruments.

a. Instrument for facilitating section of the optic nerve. Spoons, b. Meyhoefer's chalazion, c. Skeel's (serrated edge), d. Olive or oval, e. Skeel's (serrated), chalazion, f. Waldeau's (German silver), g. Daviel's (long form) chalazion, h. Fenestrated chalazion, i. Hebra's (oval) chalazion, j. Round, k. Graefe's (shell), l. Lange's (sharp, for lachrymal sac), m. Bunge's exenteration, n. Hess, o. Knapp's (silver), p. de Wecker's chalazion, q. r. Daviel's, s. Graefe's (shell), t. Pagenstecher's (platinum end), u. Pagenstecher's (extraction), v. Wheeler's (foreign body).

so as to have a trough-shaped opening into which the tears may easily pass.

J. W. Walmsley (A New Tube for and Method of Operation Upon the Lachrymal Duct to Restore Tear Drainage, *Ophthalmic Record*, Aug., 1904, p. 362) describes tubes of gold or silver, telescopic and composed of two sections. The lower end is rounded with side openings for exit of fluids. The rounded end rests on the floor of the nose. They have a caliber of 3 mm.

John Green advocated the substitution of flexible styles of lead for the rigid ones of silver previously employed. They are made of the purest and softest lead, drawn into wire of sizes ranging from one to two millimeters in diameter. *(Trans. Am. Oph. Soc.*, 1868, p. 31.)

In 1869 Green remedied the difficulty of manipulating the very flexible lead wire, especially the smaller sizes, by making the styles

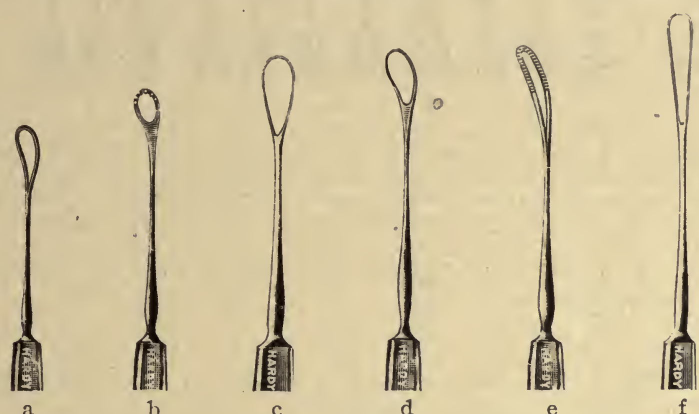


Fig. 166.

Loops. a. Bowman's (fenestrated), b. Noyes' (toothed), c. Weber's (wire), d. Levis' (fenestrated), e. Arlt's (serrated), f. Snellen's (wire).

tubular and inserting a stylet of tempered steel wire. The stylet is withdrawn as soon as the style is placed in position. *(Trans. Am. Oph. Soc.*, 1869, p. 16.)

Repositors.

The iris repositor or spatula is made in tortoise-shell, hard-rubber and silver. The blade should be about 8 mm. long and 2 mm. wide with the extremity blunt to prevent wounding the iris.

Spoons.

Under the head of spoon-shaped instruments may be classed the scoops of Daviel, Graefe, Pagenstecher, Knapp, Critchett, Noyes and others; the chalazion curettes of many models, enucleation spoons and exenteration scoops.

G. Hays' enucleation spoon *(Trans. Am. Oph. Soc.,* 1874, p. 214) is a two-branched blunt spoon. The branches are smooth, thin plates, so shaped as to fit the posterior surface of the eyeball. They are somewhat parallel with each other, long enough to pass about three-quarters the way around the posterior half of the eye, and sep-

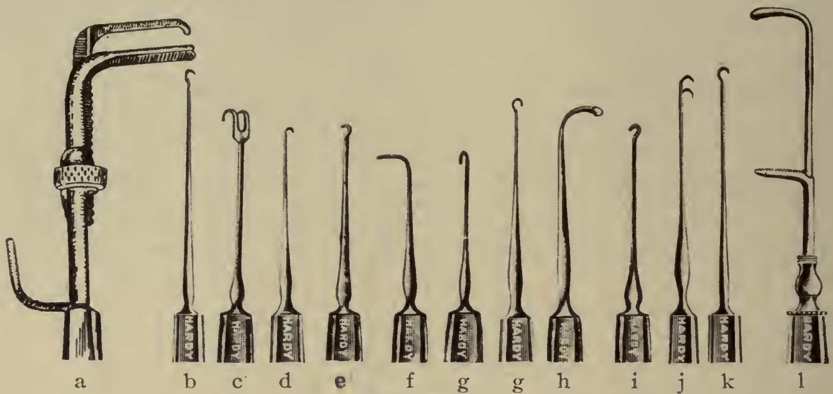


Fig. 167.

Hooks. a. Double Hook for Use in Advancement Operation, b. Jaeger's (sharp iris), c. Double fixation, d. Beard's (extraction), e. Blunt iris, f. Stevens' (squint), g. Tyrrell's (blunt iris), h. Graefe's (squint), i. Sharp iris, j. Weber's (double), k. Himly's (blunt iris), l. de Wecker's (double).

arated by an interval of a quarter of an inch to allow the optic nerve to pass between them.

Loops.

The loop is used to assist in the delivery of a lens during the op-

Fig. 168

Spuds. a. Dix, b. Grooved, c. Foreign body.

eration for the extraction of cataract. The different models are largely modifications of the Graefe wire loop.

Hooks.

This class of instruments may be subdivided under the heads of

strabismus or tendon hooks, *capsule* hooks, *iris* hooks, both sharp and blunt, *fixation* hooks. Models of each class are shown in the illustrations.

The blade of R. H. Elliott's instrument (An Optic Nerve Hook for Use in the Operation of Optico-ciliary Neurotomy; *Trans. Oph. Soc. United Kingdom,* 1909, p. 219) is 5 cm. long. The large curve of the blade has been moulded on the antero-posterior curvature of an average eye, and corresponds to a little less than half its circumference. The extremity of the hook is bent back 4 mm. in the smaller curve, the opening of which has been so graduated that it will admit and hold firmly an optic nerve.

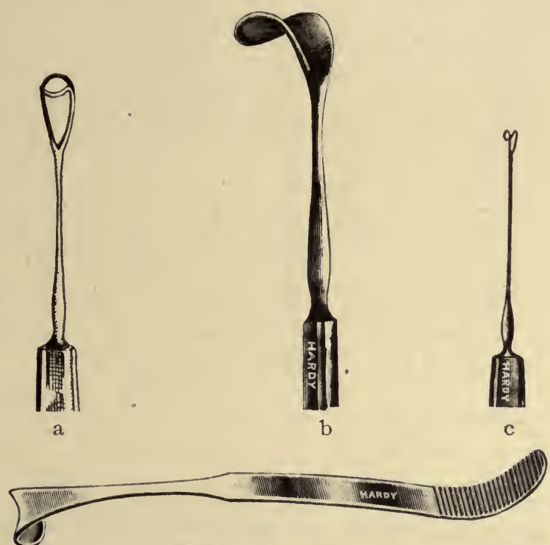


Fig. 169.

Retractors. a. Cataract (lid), b, Desmarres' (lid), c. Graefe's (lens), d. Fisher's (lid).

H. Knapp's hook for extracting foreign bodies from the eye (*Trans. Am. Oph. Soc.,* 1873, p. 107) is quite small, grooved and roughened on its concave side and made of flexible silver, so that its curve may be changed to suit the case.

Spuds.

For the removal of a foreign body imbedded in the cornea the narrow bladed, sharp pointed Graefe knife is as good an instrument as can be found, but very practical models of Dix, Todd, Becker and others are here illustrated.

F. C. Todd's instrument *(The Ophthalmic Record,* May, 1906,

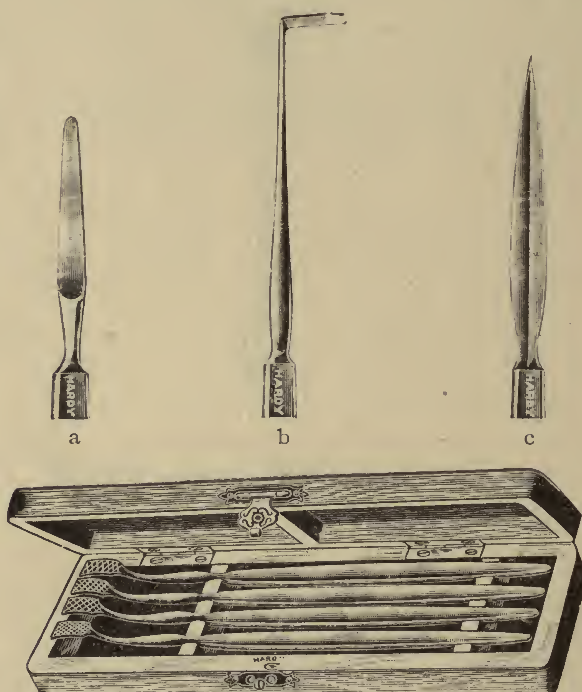
p. 208) is made with a V- or U-shaped groove, beveled on the flat, at several angles.

A. Schapringer *(Am. Jour. of Ophthal.,* Oct., 1884, p. 200) has invented a small scoop about 3 mm. long, attached transversely to the shaft of the instrument.

Retractors.

The Desmarres retractor is the most widely known; among the other models are those of Stevens, Walton and Noyes.

A. E. Prince's instrument (Cataract Lid Retractor, *Ophthalmic Record,* Jan., 1907, p. 19) is provided with two fenestrated loops. One is the retractor; the other extends forward beyond the retractor and



a b c

d

Fig. 170.

Instruments not Otherwise Classified. a. Beard's exenteration knife-spatula, b. Prince's divulsor, c. Beard's blunt dissector, d. Jameson's set of trachoma files.

serves to depress the superior flap while the cornea is pressed upon below by the spoon.

A lid retractor *(Trans. Amer. Oph. Soc.,* 1874, p. 215) was devised by H. D. Noyes to deal with an eye deeply sunken in the orbital cavity. It is made of stiff wire and is attached to the shank by two

branching bars. These bars are bent at a little more than right angle to the shaft which enables the operator to carry the whole lid under the orbital roof.

Ernest Moraweck has invented a wire lid elevator *(The Ophthalmic Record,* May, 1908, p. 243) which is 5⅜ inches long. The hook is of No. 14 and the fingering of No. 15, Brown & Sharpe gauge, tempered steel wire, nickeled, all parts hard-soldered.

W. E. Baxter *(The Ophthalmic Record,* Aug., 1901, p. 413) has devised a nickeled wire loop with a large retractor at one end and a small retractor at the other.

C. H. Beard's exenteration knife-spatula (*Ophthalmic Record,* July, 1905, p. 333) is double-edged, about 4 mm. wide at its broadest part, where it joins the shank, and gradually tapers to the extremity, where it is nearly rounded. It is curved on the flat for two-thirds of the distance from tip to base, and transversely convex on its outer surface. Its inner surface is flat. The edges are tolerably trenchant. The rounded end is blunt.

B.—OPHTHALMIC INSTRUMENTS WITH LARGE OR CROOKED HANDLES.

This classification is intended to include trocars, chisels, saws, trephines, punches, curettes, spatulæ, tissue-hooks, applicators.

It will be noticed that these instruments are common to ophthalmic and general practice, and beyond stating that when employed for eye operations they should be somewhat smaller and more slender than those employed by the general surgeon, it is not necessary either to give an extended description of them or to illustrate very largely the text by cuts. Moreover, when it has been necessary to refer to any special instrument in this class it will be found in the appropriate chapter.

C.—OPHTHALMIC INSTRUMENTS WITH DOUBLE OR SPECIAL HANDLES.

This class includes various forceps, scissors, needle-holders, lid-clamps, forceps-scissors, scissors-handled punches, scissors-handled forceps, chalazion forceps, pincers, etc.

Most of these instruments may be divided into subclasses as, for example, three or four variations of forceps (iris, fixation, cilia, special lid).

Rochon-Duvigneaud's spring scissors, (Une pince ciseaux pour l'incision des cataractes secondaires. *Archives d'Ophtalm.*, 1903, p. 561) has the blades so curved as to divide the membrane (in second-

ary cataract) with ease, even though it lies in contact with the cornea after the escape of the aqueous humor.

The blades are curved in the plane of their cutting edges. The lower blade is pointed in order to pierce the membrane, while the blunt-pointed upper blade by reason of its curvature passes between the cornea and cataract without being caught in the latter.

R. B. Carter's iris or capsular scissors *(Trans. Oph. Soc., U. K.,* 1886, p. 496) is made so that the blades are anterior and posterior; the anterior blade smooth and rounded, so as to glide easily along the inner surface of the cornea, the posterior blade sharp so as to penetrate any tissue to be divided. They are made with flat spring handles.

The general shape of the scissors is the same as that of the well-known de Wecker's scissors, but the blades are turned in the opposite direction to the usual pattern, and lie closed instead of open when the

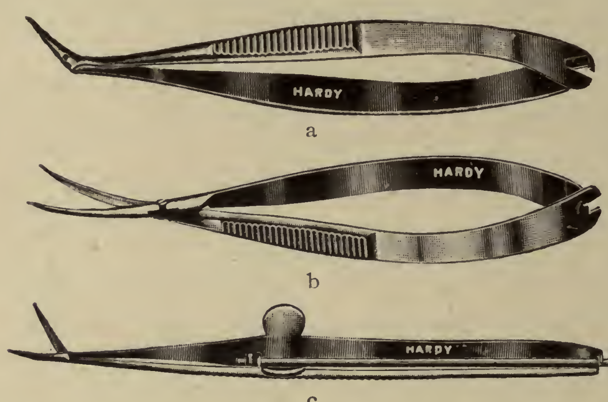


Fig. 171.

Forceps-Scissors. a. McCluer's (iris), b. Westcott's (curved iris), c. de Wecker's (iris).

scissors are in a position of rest. The blades are sharp on the outer as well as the inner edges, so that the scissors cut *out* when the blades are opened, and *in* when the spring is allowed to close them. The blades are very fine, and will pierce a capsule as readily as a Graefe's knife. They are separated by the same action that closes the Wecker's scissors, and to an extent that can be regulated by a screw before operating.

Forceps-Scissors.

The name sufficiently describes these instruments and the special purpose to which they are adapted is indicated mostly in the chapters appropriate to their use. Illustrations of them and of the operations in which they are used will be found in their proper places.

Scissors-Handled Punches.

As in the case of forceps-scissors these instruments are also for special purposes which are indicated in the chapters devoted to their particular use.

Forceps.

Here again the remarks of Landolt *(loco cit.)* seem apropos. He reminds us that the forceps is such a simple instrument and so much in use that one would think it should by this time have attained great perfection of form, but this is not always the case, especially in those we use in ophthalmic surgery. In most of the forceps the *spring is too stiff.*

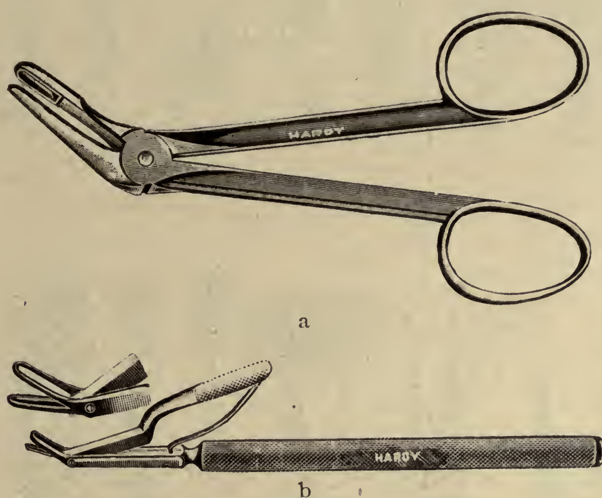


Fig. 172.

Scissors-Handled Punches. a. Arlt's (for iris growth), b. Stevenson's (capsule).

Even the ordinary forceps has often too strong a spring, whilst, on the other hand, the blades are too weak. When we seize an object with some force, like the periosteum in extirpation of the lachrymal sac, the blades touch and cause the teeth to separate, so that the intervening tissues slip away. We need a light spring and strong blades for ordinary forceps.

Another objection in most forceps is that the extremities of the blades are too long. The portion below the grip should be shortened by almost 5 mm.

A further remark concerning the *teeth of the forceps:* "We rarely apply the forceps perpendicularly to the object we seize. Generally the forceps make an angle of 45 degrees with the surface upon which they are to act, and consequently only one or two of the teeth are in

Fig. 173.

Forceps. a. Dressing, b. Förster's (capsule), c. Critchett's (fixation), d. Fischer's (iris), e. Fischer-Arlt's (iris), f. Liebold's (iris), g. Broad cilia, h. Narrow cilia, i. Strabismus, j. Reisinger's (iris hook), k. Fixation forceps (with catch), l. Prince's (advancement), m. n. o. Kuhnt's (expression), p. Liebreich's (rotary iris).

contact with the tissues. In order to remedy this inconvenience, I have for many years had my forceps made so that the teeth are placed obliquely to the blades and perpendicular to the surface we wish to seize."

"These forceps are made with two or three opposing teeth, in models of different strength.

"A forceps which I have had made for a special purpose is different from the usual one. This is the forceps I use when I cut a buttonhole through conjunctiva and Tenon's capsule for operating on an ocular muscle. The introduction of the muscle-hook is only successful when we can see the sclerotic at the bottom of the buttonhole; it is only then that the hook will slip under the muscle without folding it. With an ordinary forceps one gets insufficient hold of the tissues. The layers which cover the muscle are so many that, when one tries to incise them successively, one almost always goes astray, and is surprised at the delay in reaching the sclera. I have had this model constructed with very sharp teeth, so that they lock with the points crossing one another *(crossbill forceps)*. With this forceps one grips the tissues much deeper and usually succeeds in cutting at once to the sclerotic."

C. H. Beard's fixation forceps (*Ophthalmic Record,* Feb., 1907, p. 62) is an adaptation of Mathew's forceps-scissors. The scissors blades are left off and in their place are the members of the forceps. Instead of moving in the same sense as the scissors the lower portions of the instrument are given a quarter turn, so that they are set in a position at right angles to that of the scissors. When applied to the eye the body of the instrument assumes a vertical position.

Köster-Gzn's fixation forceps (Eine Fixationspinzette, *Zeitschr. f. Augenheilk.,* XVIII, No. 6, 1907, p. 521) are bent at the ends at an angle of 45 degrees. The teeth are placed as if the forceps were straight.

A. E. Prince's fixation forceps (*The Ophthalmic Record,* Jan., 1907, p. 19) is borrowed from Critchett of London. The instrument is made short to secure rigidity, the points curved and the fixation ends so sharp that they will pierce the sclera, and so guarded that they will not perforate this structure. This is effected by an overlapping of the points against a shoulder in the opposite blade.

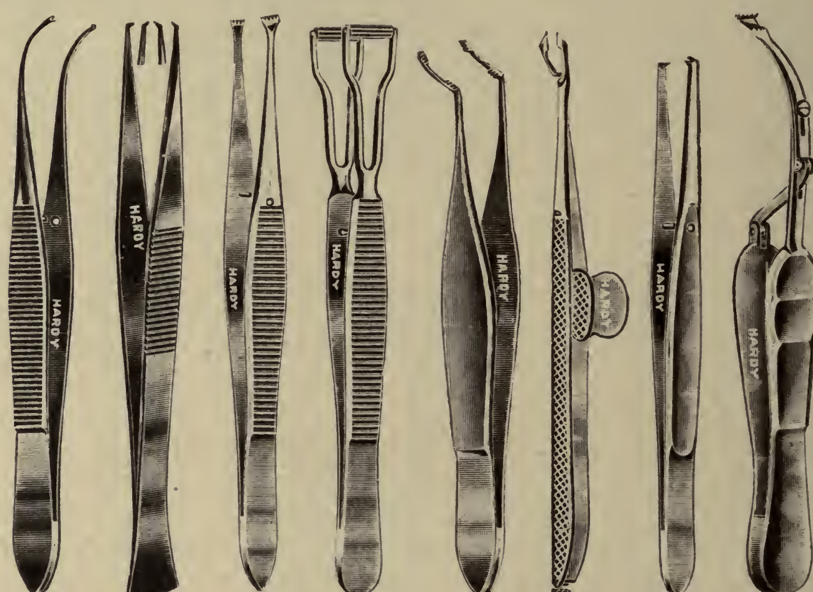
Lucien Howe has devised fixation forceps (*Am. Jour. of Oph.,* June, 1896, p. 166) the body of which is of the crossed blade spring type. The fixation ends are bent in a half circle and there is a projecting pin on the forceps to catch over the lower bar of the speculum and hold the eye from rotating upward.

H. D. Noyes' fixation forceps (*Trans. Am. Oph. Soc.,* 1874, p.

216) has crossed blades and a stiff spring to keep them shut. It is curved in an S-shape, and rides over the lower blade of a wire speculum.

A. Critchett's fixation forceps (*Trans. Oph. Soc. U. K.*, 1888, p. 322) has fine curved teeth that are readily embedded in the subconjunctival tissue. A shoulder on each blade prevents too deep penetration.

M. D. Stevenson's advancement forceps (*The Ophthalmic Record*, Dec., 1905, p. 574) are curved on the flat, the blades being at right angles to the handle. They become locked when the blades are closed and are released by pressing the handle.



a b c d e f g h

Fig. 174.

Forceps (continued). a. Curved iris, b. George's (fixation), c. Fixation (without catch), d. Knapp's (expression or roller), e. Tooke's (capsule), f. Beard's (fixation), g. Rat-toothed, h. Müller's (capsule).

Scissors-Handled Forceps.

It is not intended to describe each one of these instruments inasmuch as they will be found pictured in those chapters that deal with operations in which they are employed or used.

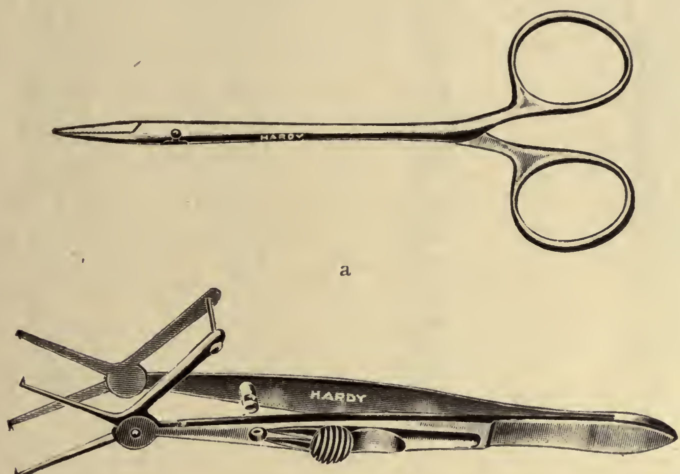
G. F. Suker's enucleation forceps (*The Ophthalmic Record*, Jan., 1902; p. 34) is sufficiently concave, curved on the flat, and large enough to hold the globe. It is modeled after the usual obstetrical forceps and is applied in a similar manner.

Lucien Howe's hemostatic forceps for use in the orbit (*The Ophthalmic Record,* Dec., 1902, p. 623) consist of a scissors-like clamp, curved on the flat, with just sufficient curve to pass conveniently into the orbit and well behind the globe.

Chalazion Forceps.

There is a large number of these forceps on the market and many others that have not gone further than their description in ophthalmic literature. The most important instruments in this class are described and pictured in the chapter devoted to Minor Operations on the Eyelids, and the reader is referred to that part of this *System.* In addition, however, a few others seem to call for comment.

H. R. Boettcher has invented a punch-forceps for chalazion with



a

b

Fig. 175.

Scissors-Handled Forceps. a. Halstead's (mosquito) hemostatic, b. Herrnheiser's (lid).

which to remove a piece of the cyst wall and establish perfect drainage. (See *The Ophthalmic Record,* Feb., 1907, p. 66.)

L. M. Francis' chalazion forceps (*Ophthalmic Record,* Dec., 1905, p. 568) is made with the curve in the upper blade so placed as to permit clamping the lid without crushing the ciliary margin.

C. J. Kipp has devised a simple chalazion forceps, one blade of which is solid, the other has a slit in it. The blade with the slit is placed over the conjunctival surface of the cyst and the incision is made through the slit. The handle is compressed and the contents of the cyst pressed out through the slit. (See *Trans. Am. Oph. Soc.,* 1898, p. 471.)

Scissors.

Landolt believes that the handling of scissors should be governed by the same principles as that of the other instruments. They should be steadied between the extremities of the fingers only, and the active part of the instrument should be as near as possible to the finger-tips. To attain this purpose the scissors should be held by the extremi-

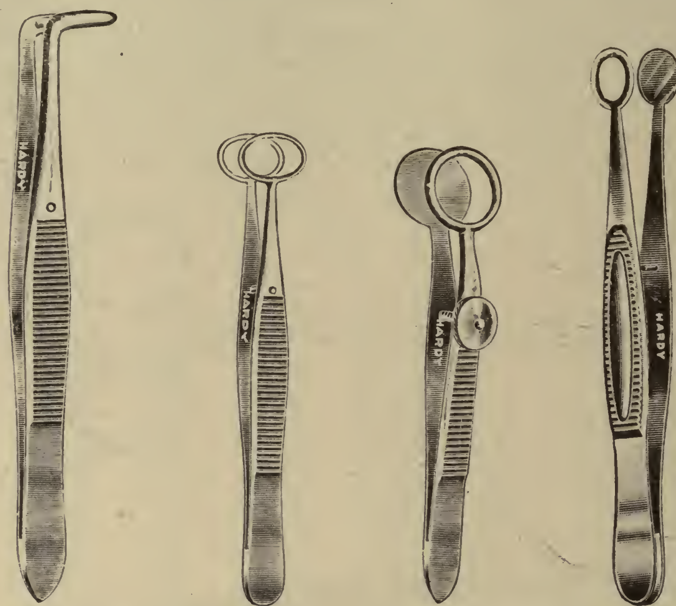


Fig. 176.

Forceps. a. Noyes' (expression). b. Prince's (expression). c. Hunt's (chalazion). d. Ayres' (chalazion).

ties of the first four fingers. The end of the last phalanges of the thumb and ring finger are delicately inserted in the rings of the scissors, so that the simple movement of those two will open or close the blades. The index finger, which, of course, should be curved, is applied to the crossing. The extremity of the middle finger is applied, on the opposite side, to the ring and corresponding handle. Thus the scissors are steadied by the thumb and ring finger on the sides, by the index finger above, and by the middle finger underneath. They can escape in no direction, and can even be turned over without any difficulty. Moreover, they can be worked with the greatest lightness.

"This method of holding the scissors has another great advantage. Owing to the fourfold contact of the instrument with the most sensitive parts of the fingers, the scissors are no longer simply a *cutting forceps,* they become a most *sensitive probe,* and can give most valu-

able information as to the nature of the tissues with which they come in contact, and as to the precise situation of the points of the blades.

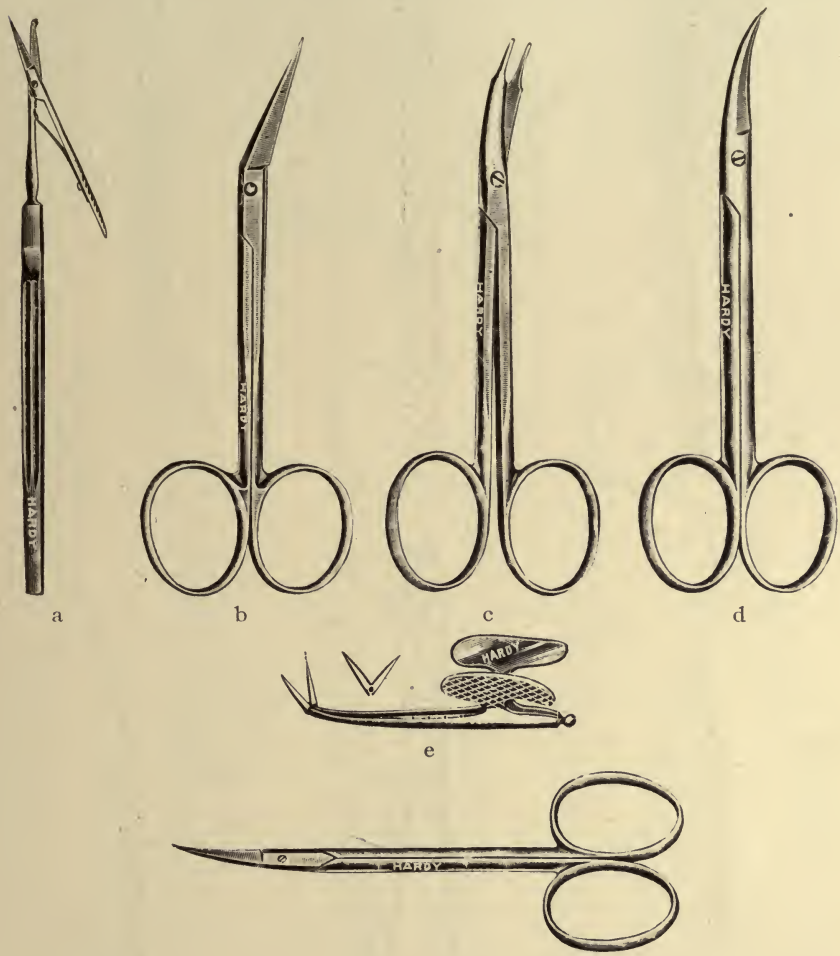


Fig. 177.

Scissors. a. Noyes', b. Angular (sharp iris), c. Blunt (strabismus), d. Stevens' (strabismus), e. Liebold's (iris), f. Small strabismus.

Moreover, the tip of the index finger being as near as possible to the active part of the instrument, it can be handled with the greatest degree of precision.

"To ensure proper handling, the scissors should be proportionate to the hand of the operator. The hand being half-opened and the thumb and ring finger being inserted in the rings, the tip of the curved index finger should rest exactly on the lock.

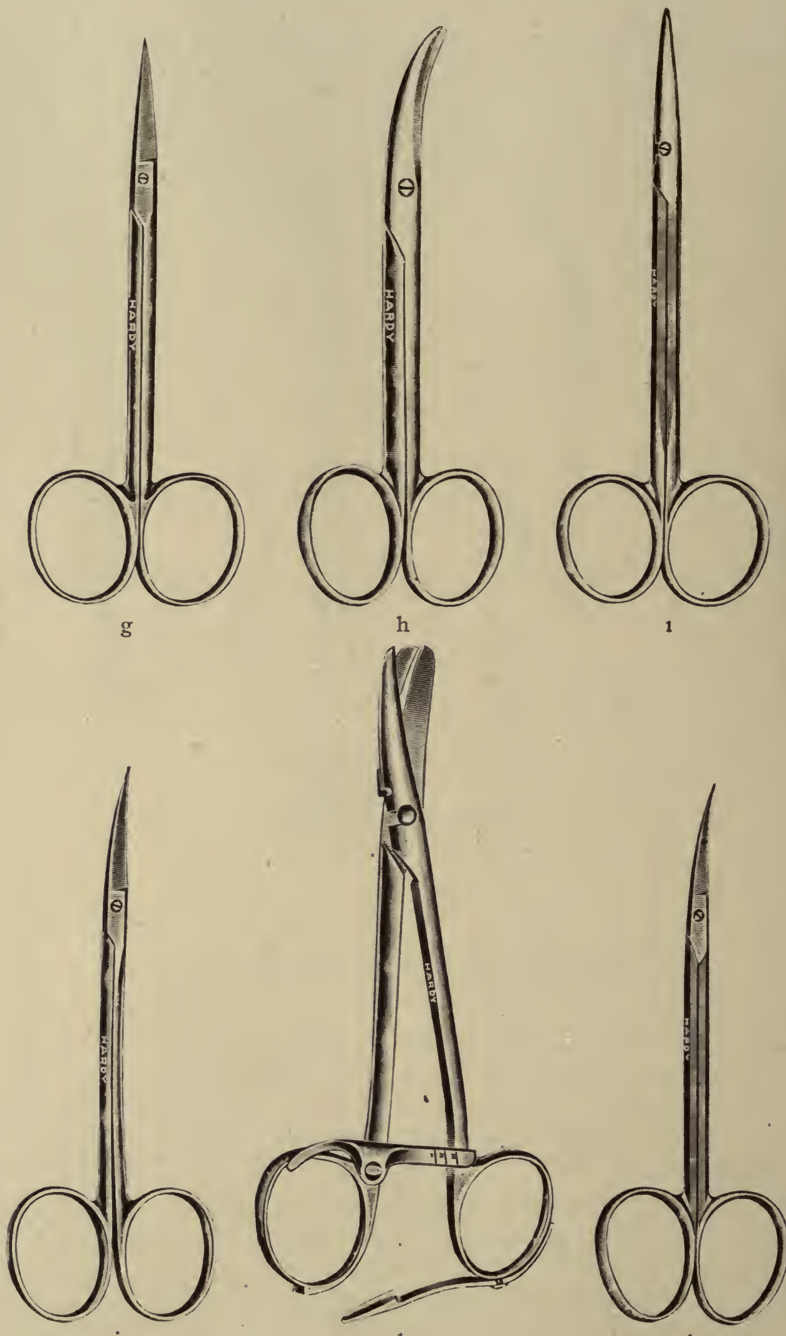
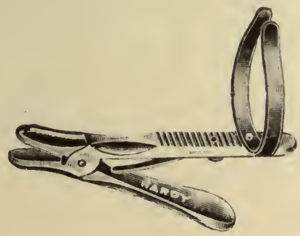


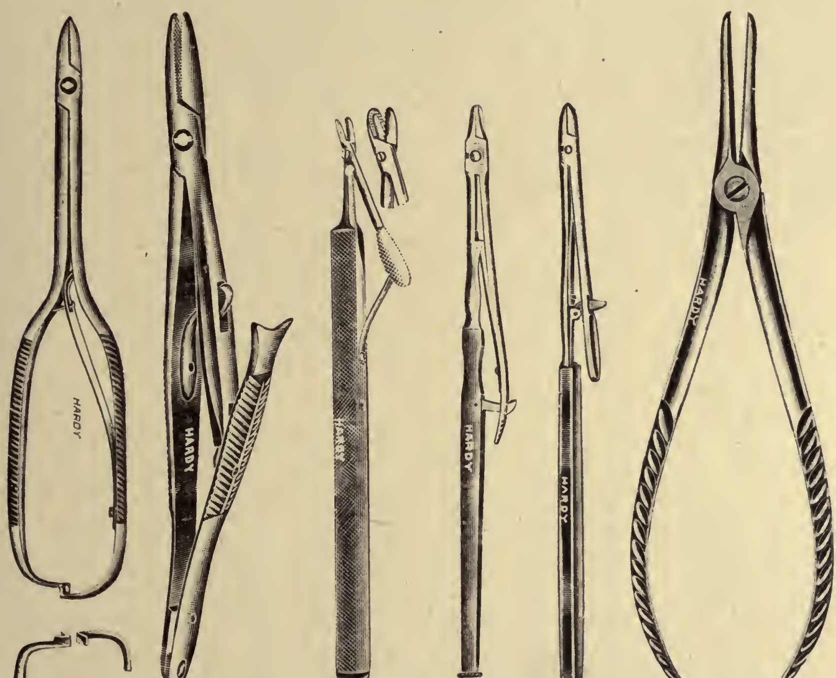
Fig. 178.

Scissors (continued). g. Straight sharp iris, h. Enucleation (slight curve), i. Blunt strabismus (straight), j. Curved sharp point iris, k. Enucleation (with hemostatic clamp), l. Sharp iris (curved on the flat).

"The scissors usually supplied to the profession do not always fullfil this condition; very often the handles are too long and the operator, if his hand is small or medium-sized, is obliged to extend outwards his index finger, and by so doing mars the lightness of his movements.



a



b c d e f g

Fig. 179.

Needle Holders. a. Galezowski's, b. Boynton's, c. Luer's, d. Stevenson's, e. Knapp's, f. Stevens', g. Langenbeck's.

Generally the scissors are unnecessarily pointed and the handle too delicate. The blades should be thin in most of the scissors used in ophthalmological practice, but the handle should be strong and solid."

G. A. Critchett's scissors for dividing anterior synechiæ (*Trans. Oph. Sos., U. K.*, 1889, p. 196) have a convex curvature of the blades

which enables them to be brought into close apposition to the posterior surface of the cornea.

P. H. Mules' enucleation scissors (*Trans. Oph. Soc. U. K.*, 1880. p. 219) are ordinary strong scissors curved on the flat, but with the addition of two sharp points projecting backward at an angle of 35°, which rotate and lift out the globe at the same time.

Wm. Ellery Briggs' ablation scissors (*Archives of Ophthal.*, Vol. XVI, No. 1) consist of two curved scissors, placed parallel so as to enable one to cut a section of the optic and ciliary nerves without cutting any of the ocular muscles.

In 1894 Dr. Briggs modified his ablation scissors by adding a pair of claws between the two scissors to insure the removal of the cut section of the nerves. (See *Trans. Sec. Oph., A. M. A.*, 1894, p. 177.)

C. Griffin Lewis' new instrument for partial tenotomies (*Annals of Oph.*, April, 1907, p. 281) are scissors bent in a half curve so that a crescent-shaped piece of the muscle may be clipped off at one stroke.

C. D. Wescott's tenotomy scissors (*Ophthalmic Record*, Sept., 1897, p. 480) is a modification of the Stevens instrument and is made with spring handle.

Samuel Theobald's iris scissors (*Trans. Amer. Oph. Soc.*, 1901, p. 398) are made with the curve of the blades reversed, so that the concavity of the blades should be applied to the convexity of the corneal border. They are made with spring handle.

Needle Holders.

The importance of a properly balanced, easily manipulated needle-holder is apparent to every ophthalmic surgeon. While some maintain that an instrument without lock is the safest, in that it does away with all shock and unsteadiness in freeing the needle, there is no question but that the locked instrument gives greater freedom of manipulation and is an aid in the accurate placing of the needle. The modified Sands model with duck-bill jaws is favored by most eye surgeons. Among other models are those of Galezowski, Knapp, Horton and Sydney Stephenson.

Trachoma Forceps.

M. D. Stevenson's (A Simple Instrument for Removing the Granulations in Trachoma. *The Ophthalmic Record*, Aug., 1904, p. 357) instrument consists of two opposing blades, one solid and the other filled with as many round holes as possible, having sharp margins. The perforations should be at least 2 mm. in diameter.

Herman Knapp's roller forceps (*Trans. Amer. Oph. Soc.*, 1891, p. 148) consist of two creased steel cylinders so inserted into the

forked ends of the branches of a pair of strong forceps that they roll on each other when drawn over a body held between them.

Miscellaneous Instruments.

C. R. Agnew devised a double needle, or bident, for the removal of a crystalline lens dislocated into the vitreous chamber. It consisted of two ordinary, fine, straight, delicately pointed, cataract needles, about six-eighths of an inch long, fixed parallel at a distance a little less than an eighth of an inch apart. These needles are united at their proximal ends by a projection which is flat and roughened so as to be readily grasped by a needle holder. *(Trans. Am. Oph. Soc.*, 1885, p. 69.)

In Russell Murdoch's tenotome *(Trans. Am. Oph. Soc.*, 1874, p. 211) the blade joins the shank at an angle of 120° and is crochet-pointed to prevent the tendon from slipping off the blade.

G. C. Savage has devised a right and left-handed cataract detacher. Each end terminates in a double curve, one in line with the handle and the other at right angles to this line, the angle being at the point of union of the two curves. The two curves have the same radius, which approximates that of the anterior surface of the lens, and they are of the same length, not less than 5 nor more than 6 mm. There should be no sharpness at the angle of union of the two curves, nor at the free end of the second, or horizontal curve. The edges of each curve should be well rounded. (A New Method for Detaching the Cataract in Its Capsule, *The Journal A. M. A.*, Oct. 9, 1909, p. 1186.)

W. Watson Griffin has made a modification of Bowman's suction curette. It consists of wire wound spirally around the piston rod and fixed to the body of the instrument and the top of the piston rod. The piston is pressed down, then, on relaxing the pressure, the wire spring gently and gradually withdraws the piston and sucks up the lens material. *(The Ophthalmoscope,* Oct., 1904. p. 405).

Lid Clamps.

While many models of lid clamps have been devised they are practically all modifications of that of Desmarres. The screw lock is best adapted for the control of hemorrhage. The Snellen, Knapp, Francis, Beard and other models are illustrated in this chapter.

S. Lewis Ziegler's lid clamp *(Trans. Soc. Oph., A. M. A.*, 1909, p. 127) is a modification of his chalazion clamp, having a straight edge. It is made with a sliding catch, instead of the Desmarres screw, which facilitates placing it in position.

N. M. Black's self-retaining lid plate (*The Ophthalmic Record,* Sept., 1907) is made with the lower blade wider than the average lid

plate at the distal end. The upper blade, composed of two parts, is curved at the distal end to correspond to the curve of the lid margin; this curved end is movable in the long axis of the instrument to aid in adjustment. The upper blade is attached to the lower blade by an aseptic lock and a screw brings the blades in contact.

A. E. Ewing's improved entropion forceps (*The Ophthalmic Rec-*

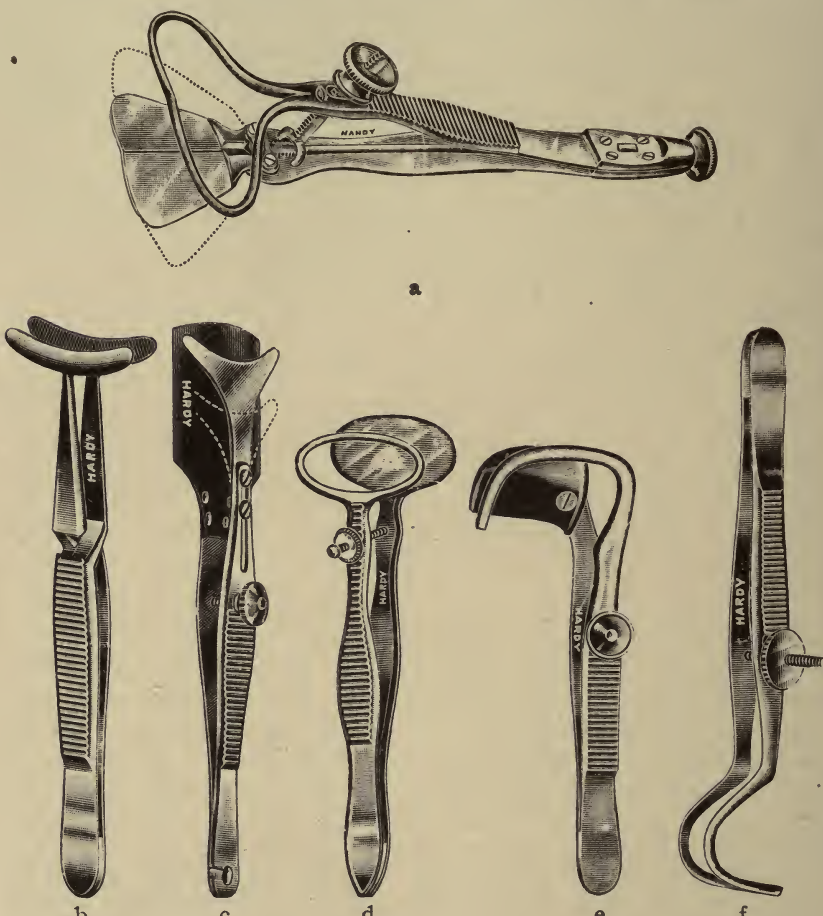


Fig. 180.

Lid Clamps. a. Warlemont's, b. Cross-bar entropium. c. Black's (adjustable lid), d. Desmarres' (lid), e. Knapp's (lid), f. Wilder's (chalazion).

ord, Oct., 1907) has improved on his clamp of 1905 by adding a broad plate, the shape of the upper tarsus, to the lower blade. The plate is about 10 mm. broad and lies in the plane of the biting portion of the blade and the tip of the handle.

C. H. Beard's lid forceps (*Ophthalmic Record,* Jan., 1905, p. 8)

are made so that the ends of the blades are bent nearly at right angles to the body of the instrument, and are curved to correspond to the natural curve of the lid margin. It is clamped with a screw attachment.

H. D. Noyes' lid forceps (*Trans. Am. Oph. Soc.*, 1881, p. 311) is a modification of Snellen's forceps, both blades being made alike.

H. Gifford (The Use of Epithelial Lip-Flaps and Half-Skin Flaps in Eye Surgery, *The Oph. Record,* Dec., 1897, p. 640), to facilitate the process of getting thin lip-flaps, has devised a large clamp of which the solid blade is smaller and set at an angle with the shank so as to pass clear through the fenestrum of the other blade. Closing the blades (the smaller one against the skin) upon the lip forces the latter into a tense prominence from which the mucous membrane can easily be shaved.

Carl Barck has devised an entropium forceps (*Am. Jour. of Oph.*, Dec., 1898, p. 366) with the blades placed T-shaped to the handles and curved to correspond to the lid margin. One branch of the forceps has a wide blade with three small holes, the other a narrow one with three teeth.

D.—Ophthalmic Instruments and Appliances Without Definite Handles.

Lid specula (blepharostats), irrigators (intraocular and other), styles, cautery appliances, and magnets.

Lid Specula.

Specula of almost every conceivable size, shape and description have been devised, but very few are of any real practical value. Most of them are too large and have too strong a spring. The simpler the instrument, consistent with its purpose, the greater its usefulness. Illustrations show the models of Graefe, Knapp, Noyes, Mellinger and others.

Russell Murdoch's speculum is a modification of his instrument of 1874.

One blade of the speculum has attached at right angles to it a bar, and to the other, in like manner, a closely fitting canula. At the end of the bar is a button which forms a shoulder that prevents the canula from slipping off. On the side of the canula is a finger-rest which also acts as a handle to slide the canula on the bar. The blades are opened by approximating the button and finger-rest, and closed by reversing the action. The lids lock the instrument. (See *Trans. of the Am. Oph. Soc.*, 1883, p. 467.)

M. D. Stevenson has devised an adjustable lid speculum that is a modification of the Mellinger speculum. The blades are smaller and

lighter and are attached to the body of the instrument by a pivot adjustment. (See *The Ophthalmic Record,* April, 1904, p. 153.)

C. H. Beard has described (*Ophthalmic Record,* Jan., 1905, p. 7) a modification of the Mellinger-Beard *blepharostat.* The lid holders are shaped to fit the concavity of the lid margins. The inner wall of the gutter conforms to the curve of the globe, and the outer wall to that of the skin surface of the lid. The inner wall of the trough is made decidedly lower than the outer.

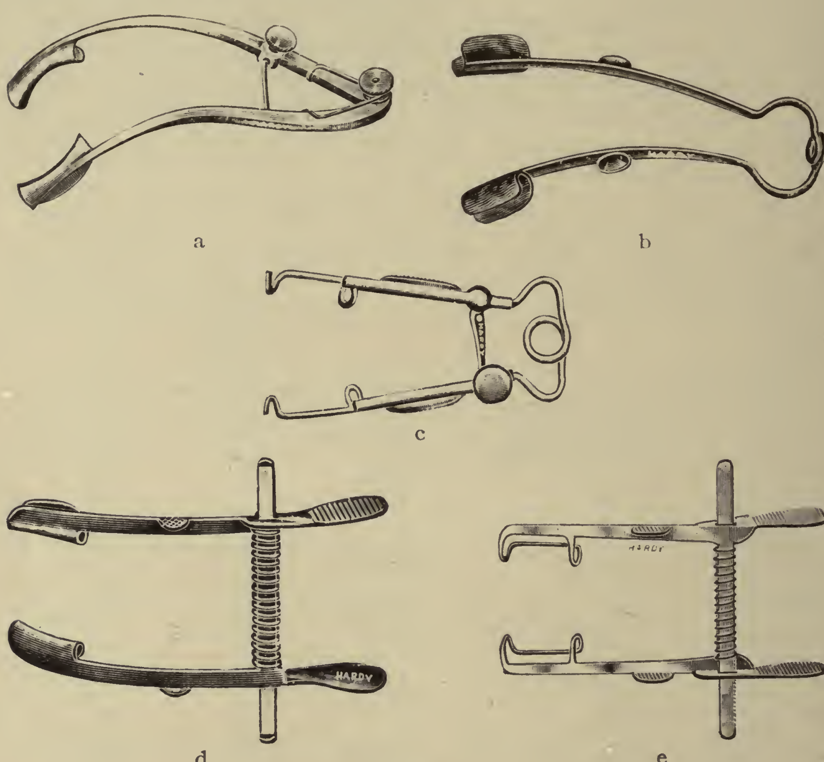


Fig. 181.

Lid Specula. a. Lange's, b. Stevens', c. Landolt's (nasally operated), d. Mellinger-Beard's, e. Mellinger's.

The lid speculum suggested by Pedrazzoli (*Arch. d'Opht.,* XXII, 7, p. 456, 1902) for opening the lids in cases of extreme blepharospasm has the size and form of a Péan's speculum. The branches, which are introduced from the temporal side, are flat and have a space corresponding to the cornea. When drawn apart they make a rotary movement, so that the lower margin of the branches eventually lies in the retro-tarsal fold.

K. Emanuel's new lid holder (*Klin, Monatsbl. f. Augenh.,* XIV,

11, p. 563, 1906) is a modification of Schmidt-Rimpler's springless lid speculum made in accordance with Hess' principle.

Paul Greven has invented a very simple speculum which has no screw parts, consisting simply of a curved spring and lid retractors.

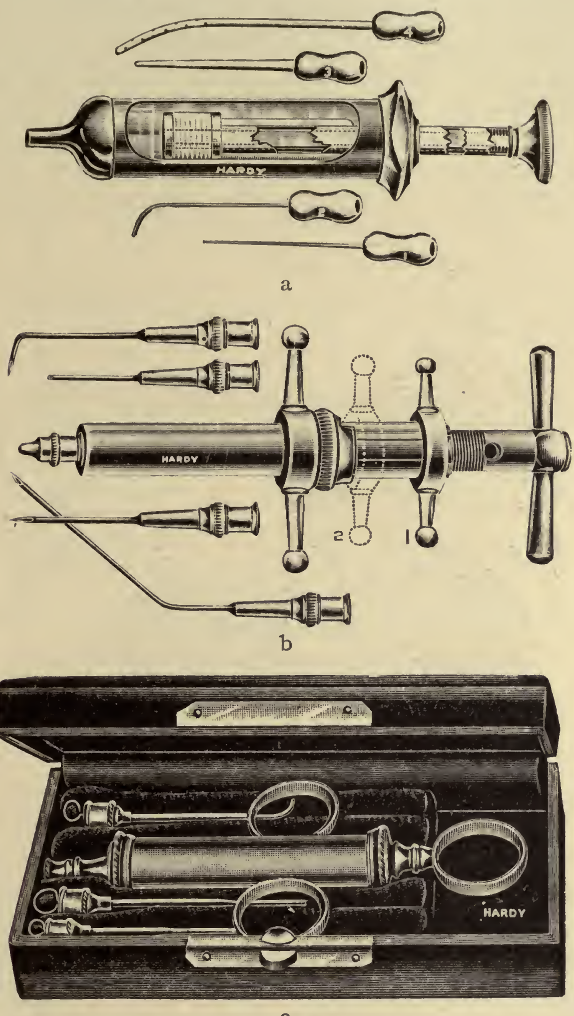


Fig. 182.

Syringes. a. Wilder's (lachrymal), b. Beck's (paraffin), c. Anel's (all metal lachrymal).

(See, Ein neuer Lidhalter, *Wochenschrift für Therapie und Hygiene des Auges,* August, 1906.)

H. D. Noyes' eye speculum is made of moderately tempered steel, electroplated with either gold or nickel. It is both light and strong.

Its blades open by a spring on the temporal side, which is so strong as to overcome the efforts of the orbicularis even when it contracts vigorously. The check to the expansion of the blades is found in a Y-shaped attachment to the upper side of the arms. The extremities of the Y are pivoted to the arms and to the stem, so that it has three joints. The stem is prolonged backward beyond the spring, and runs through a short tube soldered to the spring. A triple thread is cut on the stem, upon which a milled head runs easily and quickly. The head may be set at any point of the screw and effectually stops the expansion of the blades, but does not hinder the closure of them by the fingers of the operator. (See *Trans. Am. Oph. Soc.*, 1869, p. 54.)

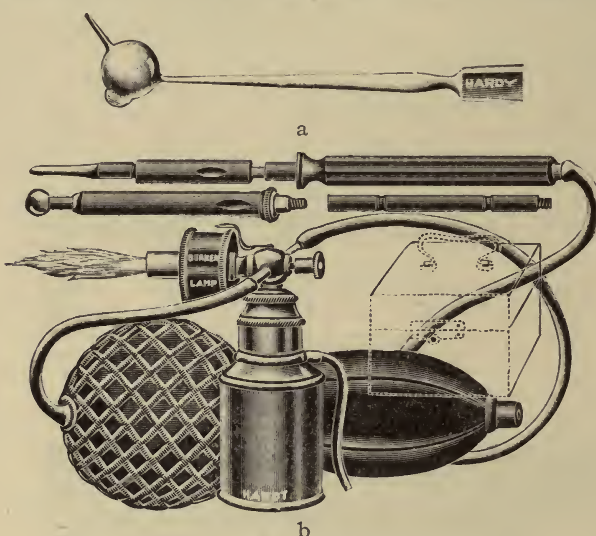


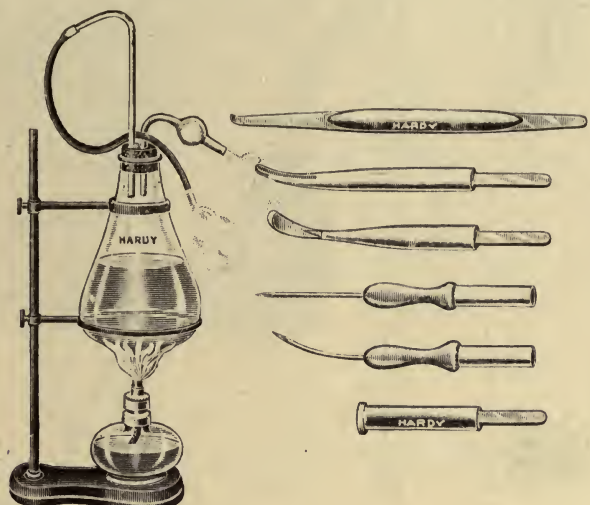
Fig. 183.
Cautery Appliances. a. Wordsworth-Todd, b. Paquelin.

N. Bishop Harman describes a new retractor for use in excision of the lachrymal sac. By an alteration of the prongs at the extremity of the laterally acting blades, and the addition of a claw which can be drawn back by the milled nut at the spring end of the frame, this retractor exerts the powerful tractor action of Axenfeld's instrument, and yet leaves the upper end of the site of the operation free. The front claws on the blades are pointed and so shaped that they oppose the backward drag of the long claw. (*The Ophthalmoscope,* Nov., 1909, p. 745.)

Sydney Stephenson's lachrymal retractor has four fork-shaped blades, each provided with three pointed prongs. The blades are actuated by the screw and can be brought into apposition for the purpose of introduction into the wound, and then separated to the required

extent by reversing the action of the screw. The blades are fitted to the arms which carry them by swivel attachments. *(The Ophthalmoscope,* Jan., 1909, p. 21.)

G. Stanculeanu has invented a speculum for excision of the optic nerve. The instrument consists of two blades linked together by an articulation similar to that of Doyen's mouth speculum. One



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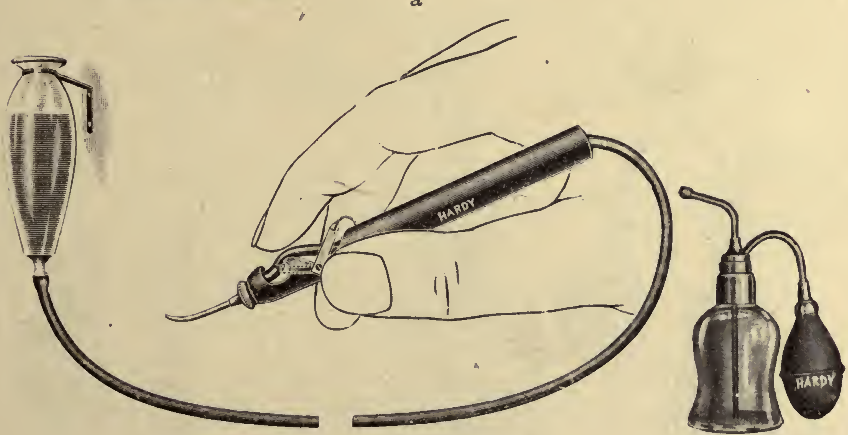


b c

Fig. 184.

Irrigators. a. McKeown's, b. Lippincott's, c. "Improved."

of the blades has at its end a hollow spoon, and the other a hollowed spatula. When the blades are separated the spoon causes the globe to spring forward while the spatula presses the tissues back in the orbit. (*The Ophthalmoscope,* July, 1909, p. 472.)

Fig. 185.

Irrigators (continued), a. Ziegler's, b. Callan's, c. Allport's (anterior chamber), d. Elwood's, e. Dropper bottle, f. Todd's.

Syringes.

Most of the lachrymal syringes are modifications of the Anel model, as shown in the instruments of Agnew, Wilder, Kirkendall, Stevenson and others. Of late years a number of syringes have been devised for the injection of paraffin into the tissues, notably the models of Beck-Mueller and Harmon-Smith.

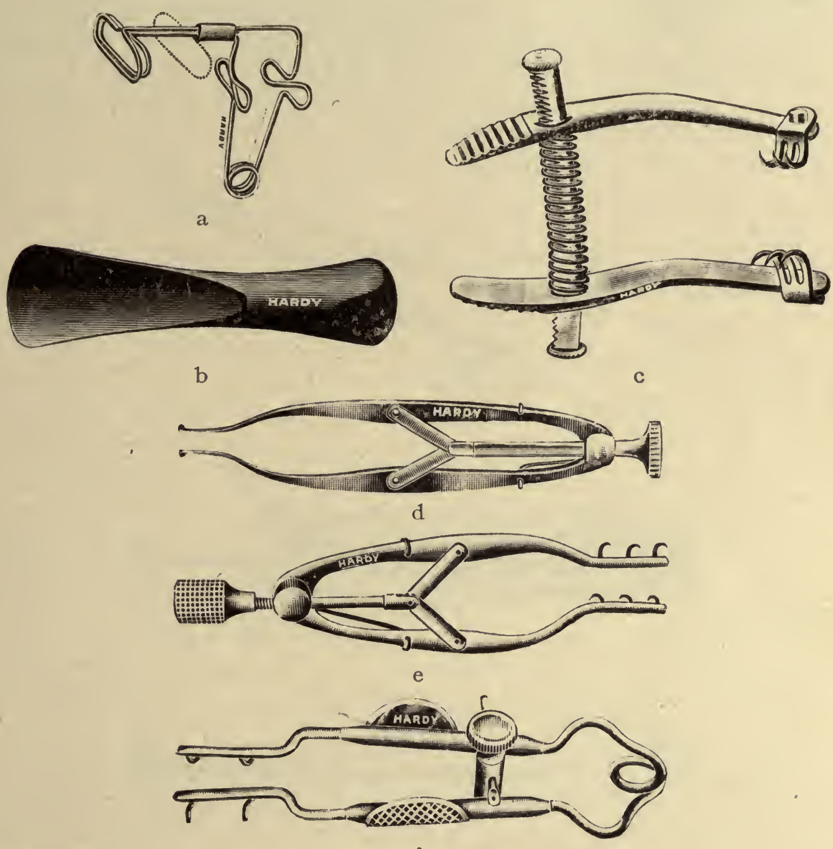


Fig. 186.

Instruments not Otherwise Classified. a. Lewis' lachrymal sac clamp, b. Jaeger's hard rubber lid holder, c. Axenfeld's lachrymal sac retractor, d. Todd's tendon tucker, e. Stevenson's lachrymal sac retractor, f. Müller's lachrymal sac retractor.

W. H. Wilder's lachrymal syringe has a glass barrel larger than that of Anel. It is held by a metal jacket, made of one piece, to which a collar is screwed at the upper end. The piston is wrapped with asbestos string and is expansible by means of the screw in the piston rod. (*Ophthalmic Record,* 1906, p. 3.)

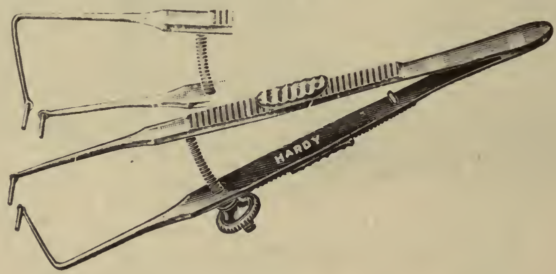
J. S. Kirkendall's new lachrymal syringe is a modification of the ordinary lachrymal syringe. It has a short barrel and needle. (*Ophthalmic Record,* Oct., 1904, p. 452.)

Bates pictures a *glass pipette for washing out the lachrymal sac.* He believes it to be an improvement on the Anel syringe. (*Archives of Ophthalm.,* 1901; p. 514.)

Cautery Appliances.

The reader is referred to Thomson's chapter for a description of electric cautery appliances and magnets.

A description of several modifications of the Paquelin cautery will be found in the text of this chapter.



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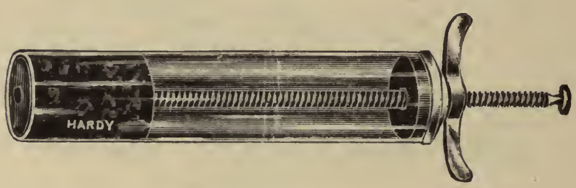

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i

Fig. 187.

Unclassified Instruments (continued). g. Green's improved tendon tucker, h. Heurteloupe's artificial leech, i. Mules' repositor.

Sydney Stephenson's improved thermo-cautery for eye work consists of a hollow handle which acts as a combined reservoir and vaporizer. This receptacle is lined with cotton wick, which is saturated with hydro-carbon (petrol) before using the instrument. The trunk comprises an aërator, a refrigerator, a stop-cock and a collar, kept in place by a spring. The collar carries an index and an air tube, the latter forming an attachment for a rubber bellows and tube. A heat-resist-

ing block contains a gauze septum, and a standard, to which the working parts are secured. The points are of platinum. (*The Ophthalmoscope,* Dec., 1905, p. 610.)

E. B. Coburn's modified Pacquelin cautery for ophthalmic use consists of a brass tube or handle, 4 inches long and ½ inch in diameter. One end is furnished with a nipple, to which a rubber tube, connected with the rubber bulbs, is attached. At the lower end of the tube is fitted a bone plug, perforated with a small hole to allow benzine vapor to pass to the platinum tip. The platinum point attached to the bone plug has one side pointed and the other rounded. The cavity of the handle is loosely filled with wicking of coarse asbestos fiber. About ten drops of benzine are dropped into the handle before using. (*Annals of Ophthalmology,* Jan., 1907, p. 104.)

Irrigators.

As this class of instruments has been fully described and depicted in Wood's chapters on Minor Surgery and on Extraction of Cataract, it will not be necessary to refer to them here.

J. A. Lippincott's intraocular syringe consists essentially of a piece of black rubber tubing with a curved flat gold nozzle at one end, and a small metal reservoir at the other. To control the movements of the nozzle the latter is fitted into a hollow, hard-rubber handle, through which the rubber tubing passes. To the handle is attached a short, metal piston which can be pressed by the index finger down upon the tubing and thus stop or retard the current. (*Trans. Amer. Oph. Soc.,* 1889, p. 341.)

E. C. Ellett's combined anterior chamber irrigator and lachrymal syringe is similar in most respects to the Keyser instrument. The body of the instrument is of glass; the tip of gold. Rubber dam covers the larger end of the body. (*Ophthalmic Record,* March, 1905, p. 134.)

Joseph A. Andrews' syringe to remove cortical matter in cataract extraction is simply a half-ounce bottle, fitted with a hollow ground stopper drawn out into a tube which terminates in a smooth point and is slightly curved. A rubber nipple serves to draw up and inject the fluid contained in the bottle. (*Trans. Am. Oph. Soc.,* 1892, p. 455.)

Allen Greenwood's intraocular irrigator consists of a metal tube through which a rubber feed tube passes. It is made very thin, light and about the size of a pencil. Half an inch from the end a crescent-shaped segment is removed to allow the finger tip to compress the rubber tube and control the flow. A small metal rod extends across the concavity of the tip, which serves to elevate the corneal flap and permit a free return of the fluid from the anterior chamber. (*Ophthalmic Record,* June, 1906, p. 264.)

Testing the Sharpness of Instruments.

Priestley Smith's[2] device for determining by actual measurement the pressure necessary to puncture or cut the leather of the test drum is a valuable appliance. From the illustration it will be seen that it cuts on the principle of a see-saw. One arm is provided with a drum covered with a piece of thin, white kid, as in the ordinary test-drum. The other end of the beam is marked with a scale indicating grammes.

To test the point of a knife, the drum is placed with the leather in a horizontal plane, the point is gently pressed against the leather and the weight is moved down the scale until the knife persistently punctures the leather instead of depressing the beam. The position of the weight shows the pressure required to effect the puncture. All punctures should be made in the transverse diameter of the drum, as shown by a mark on the beam, so that they may all be at the same distance from the fulcrum. A slight rotation of the drum will bring fresh portions of the leather into position as required.

To test the edge, the drum is placed on its side so that the leather is in a vertical plane, and the knife, passed through a slit in the leather, is pressed vertically downwards without thrusting or sawing movement. The cutting pressure is found by moving the weight as before.

Sharp Graefe knives were found to *puncture* at a pressure of from one to two grammes. They *cut* at from ten to fourteen grammes and as a rule they cut more easily near their point.

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[2]Smith. A Balance for Knife Testing. *Ophthalmic Review*, Vol. 22, 1903, p. 211.

CHAPTER VIII.

OPHTHALMIC HOSPITALS, HOSPITAL WARDS AND ROOMS; THEIR FURNISHING AND EQUIPMENT.

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Hospital Construction—Ventilation—Size of Ophthalmic Rooms and Wards—Ward Furnishings—Wards for Major Ophthalmic Operations—Operating Rooms and Their Furnishings—Some Private Ophthalmic Hospitals—Ophthalmic Wards in General Hospitals—Trained House Surgeons—The Ophthalmic Nurse—Amphitheatre Operations—Sterilizers and Sterilizing—Instrument Sterilizer—Dressing Sterilizer—Water Sterilizer—Sterilizers for Pans and Other Utensils—The Furniture of Ophthalmic Operating Rooms—The Ophthalmic Operating Table.

HOSPITAL CONSTRUCTION.

Although Ophthalmic Hospitals do not differ materially from those built for the care of general surgical cases, yet there are many details of the former that call for separate treatment.

So far as the comfort and well-being of the patients, as well as the absolute necessity for surgical cleanliness in the wards and operating rooms are concerned these details are much the same. As in all hospitals, the wards should be constructed with a view to securing conditions favorable to the treatment of the diseases involved.

One of the first essentials is the protection of the patient against fire by the construction of fireproof buildings. The wards should be built so that an abundance of fresh, clean air and sunlight is admitted to them without exposing the patients to unnecessary drafts and the glare of the sun's rays.

Ventilation.

The question of ventilation is of the greatest importance and, without doubt, natural ventilation through open windows is the best. According to Ochsner and Sturm*, "Transoms should be provided in the windows which, when open, will throw the entering air upward

*Ochsner and Sturm. *Organization, Construction and Management of Hospitals.* 1910. Cleveland Press, Chicago.

so that the entering cool air will mingle with the warm air of the upper room before descending to the floor; drafts will be reduced and inflowing air will be tempered before the breather is reached. The benefits of such a method of ventilation are important and large, provided the inflow of air is free and that harmful drafts and chilling effects are eliminated."

Ventilators may be inserted under the sash of the windows, some of which have an automatic device for the control of air by means of a swinging shutter. They may be built into the masonry work of the building, preferably in panels under the window, so that the air entering is brought directly in contact with the heating surface of the radiator and the chill taken off. The inlets for the air should be between beds. In all forms of natural ventilation it will, of course, be necessary to have some outlet for the air in the room in order to create the circulation necessary for ventilation. The doors should be provided with transoms and the corridor could thus be made a large and voluminous vent duct. Adequate means should be provided at the opening of each corridor for carrying off the air which comes through the transoms. This can be done by means of ducts built through the wall above the windows, thereby creating a draft through the corridor.

Unfortunately, owing to the severity of the climate in many sections of the country, it becomes too cold for the air supply of the hospital to come directly from the outside through the open windows or through ventilating flues in the walls. It is then necessary to force air into the wards and rooms by means of revolving fans and other mechanical means.

Ochsner* advises that, in this contingency, "It should first be washed by passing through strands of oakum or other similar material suspended in the horizontal portion of the air shaft, a small amount of water being permitted to trickle over these strands constantly, then it should pass through a long shaft, extending preferably through the entire length of the building. This shaft should contain coils heated with steam or water. The outside of the shaft should be covered with some material which prevents the radiation of heat in order to economize fuel. Taking the air from a tower some distance above the roof of a high building, it is nearly free from microorganisms; this can be freed from particles of dust and dirt and introduced into the hospital clean and heated to the desired temperature. The foul air can be carried out of the rooms and wards through flues opening near the floor."

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*Ochsner. Essentials in Construction of Hospitals in Large Cities. *Jour A. M. A.*, Nov. 2, *1902*.

The *floors* should be constructed of hardwood and covered by some material which can be easily cleaned and is impermeable to moisture.

The *walls* should be covered with enamel paint which can be thoroughly washed and scrubbed when necessary. The monolithic type of floor, when properly laid, has proven very satisfactory. All floors and angles of the walls should have cone bases as a matter of cleanliness.

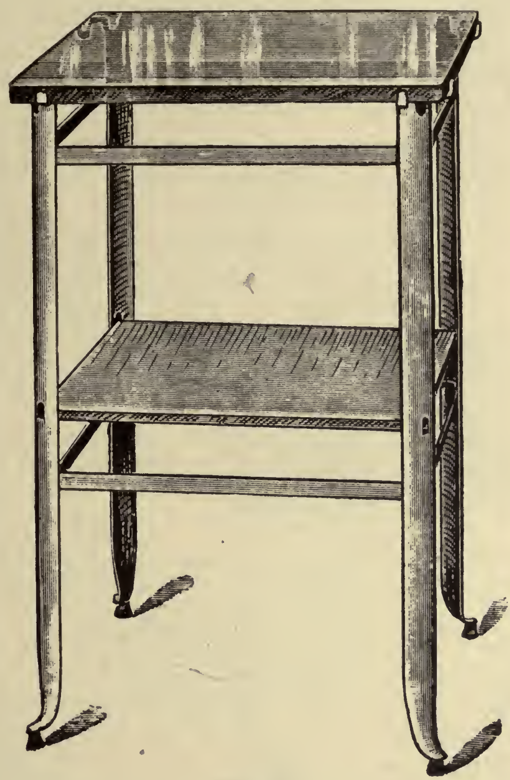

Fig. 188.
Bedside Table, New Model.

All *articles of furniture,* decoration, etc., should be of simple construction and made of non-porous material that can be easily and thoroughly cleaned. Wooden furniture is undesirable on account of its porosity, but if used it should be heavily coated with absolutely smooth enameled paint so that dirt that adheres to it can be readily washed off. Chairs, tables and beds should be made preferably of metal, either polished or covered with white enamel paint. The tops of tables should be of metal, glass or glazed earthenware. No cumbersome furniture should be given space in a ward. All draperies,

pictures and other articles of adornment should be excluded, since they collect dust and are difficult to keep clean.

The furniture of each room should consist of a bed, chair and bedside stand. The bed should be single, made of iron about 26 inches high, painted with white enamel. It should be on castors and easily movable and made with a low, movable head-piece so that operations, dressings and examinations may be readily made.

The springs should be woven wire and the mattress should be filled with horsehair. Each bed should be surrounded with sufficient space for proper ventilation, to give room for a chair and table and to allow ready access for the passage, on all sides, of the surgeon, nurse or other attendants.

The Manhattan Eye, Ear and Throat Hospital uses an ordinary 3 by 6½-foot iron bed with woven wire springs. The two end pieces are of the same height and project enough above the mattress to keep

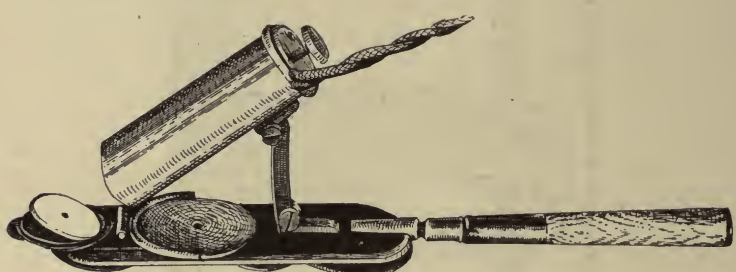

Fig. 189.

Haile's Illuminator Attachment for the Ophthalmoscope. Useful in Hospital Practice.

the pillows from sliding off. In private rooms the beds have high head-pieces which can be lifted off when desired.

Chairs should be made of iron and enameled white. The legs should have rubber tips so they will not slip and can be moved with as little noise as possible.

A *table or stand* placed at the head of the bed should be made of steel, white enameled and mounted on rubber tips. The top is best made of polished glass with a rail around three sides to prevent articles from sliding off. It may be provided with shelves of the same material and a drawer.

Each ward should be provided with a stationary cabinet constructed preferably of steel and enameled, with glass doors and sides, in which may be kept drugs of various sorts, such as atropin, eserin, etc., and various kinds of sterilized dressings, eye-shades, instruments, applicators and various appliances used for purposes of the ordinary examinations and dressings necessary in eye surgery.

Size of Ophthalmic Rooms and Wards.

The wards or rooms in ophthalmic hospitals should not be too extensive. In the Manhattan Eye, Ear and Throat Hospital they contain from ten to twelve beds; the walls of the rooms are painted dark.

Fig. 190.

Portable Corneal Microscope for Hospital Practice.

There is a large sitting room which can be made quite dark and so arranged that patients can walk about in it for exercise.

The room containing one bed is for those who are so financially situated that they are able to pay for their privacy, but does not

differ materially in furnishings from the larger ward which contains more beds. Where possible, no ward should contain more then ten beds.

Ward Furnishings.

The main point to be considered and insisted upon is simplicity

Fig. 191.
Adjustable Reflector on Stand for Operations and Examinations.

in design and furnishing. The contents of an ophthalmic ward or room should consist only of articles that are absolutely needed for the comfort and well-being of the patient and those appliances that are most needed in the proper care of the case.

Ward and Room Lighting.

To a ward devoted to the care of general surgical and medical cases it is desirable to admit much outside light; the ophthalmic ward, from the nature of the cases under treatment, should not be brilliantly illuminated.

The light should be sufficiently subdued, although it is not necessary that the room be darkened; in fact, a darkened room under ordinary circumstances is apt to be depressing to the patients. The windows should be shaded by blinds of a dark hue, and they should be adjustable and capable of being lowered to any desired height.

The *wards* should be lighted sufficiently to enable the nurses and attendants to go about their duties without undue effort. There should be no streaks or flickerings of light and the surroundings should be so arranged that all reflection is avoided. The walls and ceilings should be painted a light cream or straw color, or a very light buff.

Fig. 192.
Convenient Electric Fixture for Indirect Lighting of Rooms.

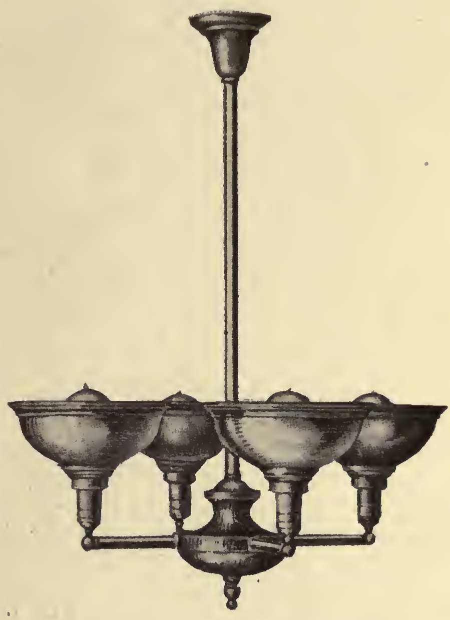

Fig. 193.
Multiple Electric Lamp Fixture for Indirect (Ceiling) Illumination.

Artificial illumination should be by means of the incandescent electric light so shaded that the rays of light are reflected only from the ceiling.

Lamps for Ward Dressing.—Where increased illumination is required for purposes of examination of the eye, the application of dressings, etc., one of the many forms of electric lamps in the market will be found useful. Plugs should be placed in the wall at the head of each bed, to which an attachment can be made for an incandescent electric light. This may be a hand lamp attached to a cord running from this plug mounted on a flexible arm, easily movable, with a frosted bulb and so shaded that the light is not only not reflected into the examiner's eyes, but shines directly on the eye under examination.

Portable Trays and Stands.

In addition there should be a portable dressing tray or ward car-

Fig. 194.

Electric Hand Lamp With Shade for use in Wards or Private Rooms for Operations, Examinations and Dressings.

riage which can be carried or wheeled from bed to bed by the nurse, on which are placed those solutions, ointments, instruments, dressings, etc., that are required at each visit of the surgeon in administering to the wants of each particular patient in the ward.

An *irrigator stand* on wheels which can be moved to any portion of the ward will also be found useful in dressing ophthalmic cases. The bottles containing the solutions should be adjustable in height and supplied with irrigator tube, stop cock and tip. It may be used, also, as a dressing stand, to avoid a multiplication of ward furniture.

Wards for Major Ophthalmic Operations.

Operative cases, especially those upon whom cataract extraction has been performed, should be kept, when possible, in a ward by themselves, hence it is desirable to have small wards so that cases can be more easily classified. All contagious cases, such as purulent ophthalmia and trachoma, should, under all circumstances, have separate accommodations. The ultimate success of an operation may

Fig. 195.
Ophthalmoscopic Lamp for Ward Practice (Gradon).

depend upon the separation of this class of cases. A separate ward should be provided for children, not only for hygienic reasons, but for purposes of quiet. Children are apt to be noisy. In addition, the children's ward may be so situated that it gets more sunlight. Separate sitting rooms should be provided for those patients who are recovering from operations and are able to be up and about. The

surroundings should be cheerful and, when possible, corridors for exercise and sun parlors should be provided.

Careful attention should be paid to the regulation of the temperature of the wards. Whatever system of heating is used, it should be regulated by such appliances as will automatically control the tem-

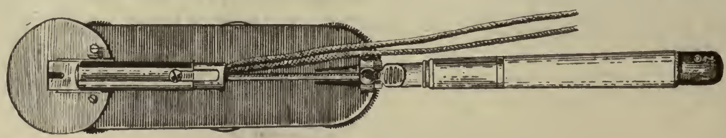

Fig. 196.
Electric Ophthalmoscope for Use in Hospital Practice (Marple).

perature and so guard against excessive heat and dryness of the atmosphere. The air should be kept moist and fresh, without drafts and without sudden changes in its temperature.

OPERATING ROOMS AND THEIR FURNISHINGS.

The ideal operating room should be at the top of the building and contain at least a single, large window with a northern exposure. Al-

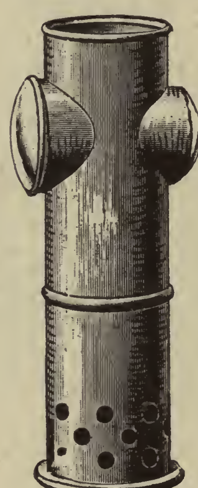

Fig. 197.
Priestley Smith's Lamp for Ward Use.

though these advantages are highly to be desired in a general surgical operating room where plenty of good daylight is required for operations, it is of secondary importance where ophthalmic operations are to be performed. In this class of operations a darkened room illuminated by artificial light is sometimes preferable to the

natural illumination. In any case, no matter from what point of the compass the room receives its light, or how good the natural illumination is, means should be provided so that the field of operation may easily be illuminated by artificial means. Electricity is, on the whole, the best illuminant, the current being controlled from a switch on a side wall. The light rays may be concentrated by means of a reflector containing a number of electric lights placed above the table and attached to an adjustable arm swung to any angle.

Fresh air should be provided without necessitating the opening of doors and windows, thereby creating unnecessary drafts or lowering the temperature of the room. The system of ventilation should

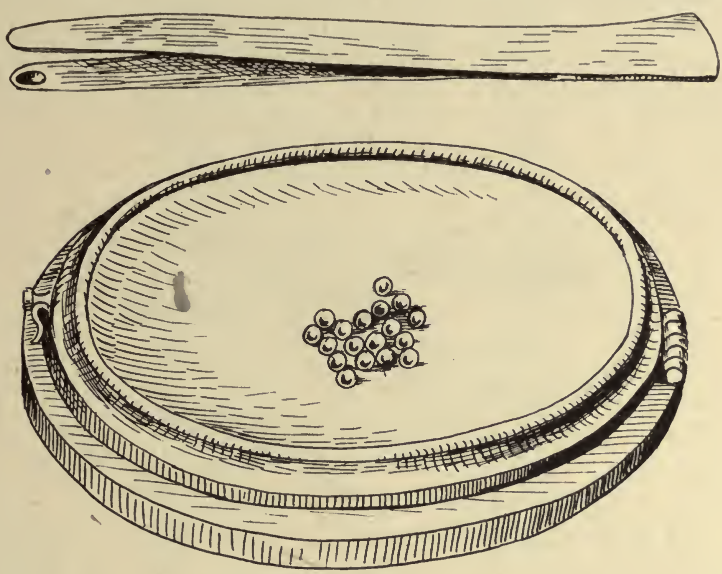

Fig. 198.
Abney Pellet Ward Test for Color Blindness (Oliver).

be so arranged that the overheated, stale air is quickly given exit from the room by means of a flue in the ceiling operated by a fan. The floors, walls and ceiling should be constructed of such material as will stand the wear and tear of use without chipping, cracking or showing roughness of surface. They should be capable of being scrubbed with soap and water and made thoroughly aseptic without injury. There should be no projecting surfaces and all corners and angles should be rounded to admit of absolute cleanliness. Probably the best, although most expensive, covering for floors, walls and ceiling is glass. It is impervious to water, oil and acids. It comes in large pieces, allowing of very few joints. It is white in appearance and very easily kept clean. Terrazzo flake mosaic and tiling laid in cement have proven

very satisfactory as to wear and cleanliness for flooring, and are much less expensive than glass. A wainscot of marble, glass or cement may be carried to any desired height and the walls and ceiling covered with a thick coat of enamel paint.

It should be possible to darken the room when necessary by *outside* shades which may be raised and lowered as desired.

There should be at least two operating rooms, one which is used exclusively for clean eye operations and the other in which only septic cases are operated upon.

Operating rooms should be so constructed that the highest possible degree of surgical cleanliness can be obtained. The doors and door-frames should be metal clad, without panels and perfectly plain. The window frames and sash should be all metal, or metal clad.

All windows and skylights should be of ground glass, especially if they are exposed to the sun's rays.

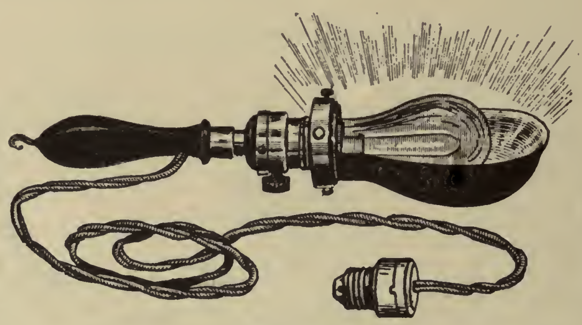

Fig. 199.
Hood Lamp for Use in the Operating Room.

The fixtures and furniture of the room should be perfectly plain and made of metal, glass, marble and porcelain, so as to admit of thorough sterilization. There should be no built-in cases and all cases should have sloping tops so as to prevent the accumulation of dust and dirt.

The operating room should contain nothing in the way of furniture, except that which is actually needed for the work to be performed. Special rooms should be provided for the sterilizing apparatus, for anesthesia and for instruments, and a preparation room for the surgeon and assistants. These should all open into the operating room where possible or be in close proximity.

Some Private Ophthalmic Hospitals.

C. R. Holmes, of Cincinnati (p. c.), whose private ophthalmic hospital is of recent date, has the floor in his operating room built of white three-inch hexagonal tiles with six-inch baseboard of the same

material, with no angles. Under the operating table electric wires for light and cautery come through the floor and are protected from water by white marble. He recommends that the walls be covered to the ceiling with white tile or marble, although to a height of six feet is sufficient, in which case the wall above should be painted with

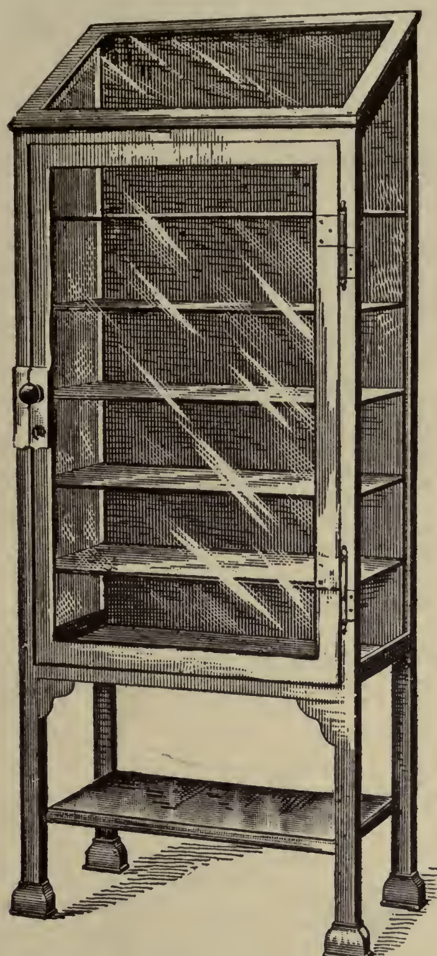

Fig. 200.

Instrument Cabinet for Ophthalmic Operating Room, With Slanting Glass Top.

smooth white enamel paint. No guards or shelves should be above the tiling.

On account of the variability of the daylight he does practically all of his operations with the aid of electric light and darkens the room by *outside* shades.

He always operates for cataract and does iridectomies with the patient in bed and in his own room or ward. The bed should be substantial and made of such height as suits the operator, the head and foot-piece of equal height. That the patient may lie firmly in bed he uses a board, 24 inches wide and the width of the bed, slipped under the wire springs and held in position by two iron fingers and two sliding bolts catching on the frame of the bed. This board is placed

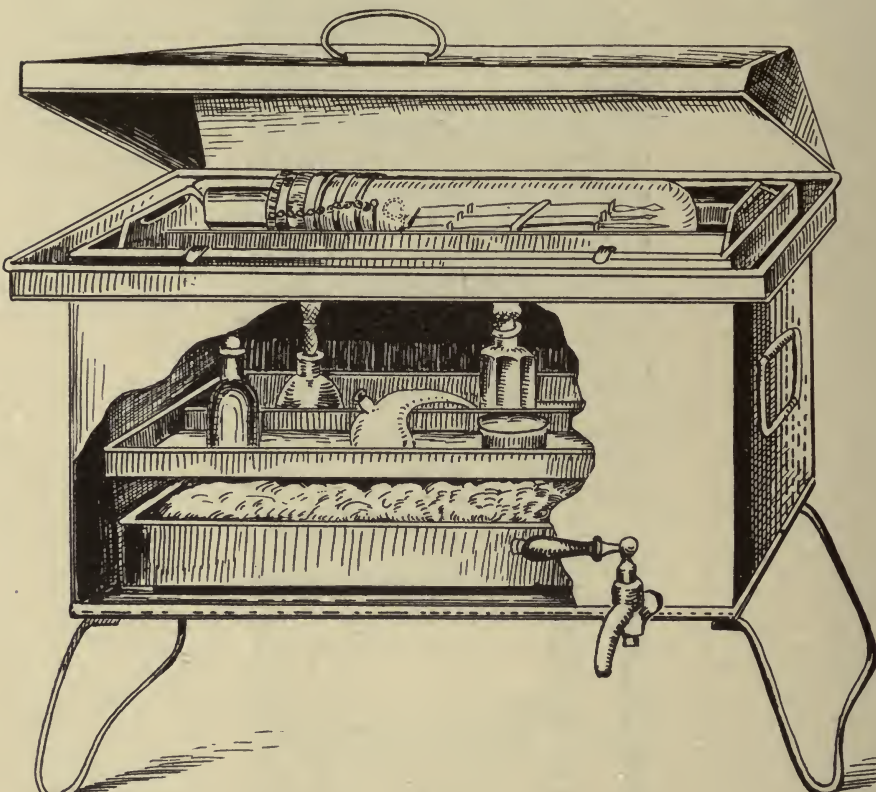

Fig. 201.
Knife Sterilizer (Grosse).

under the patient's hips and after operation is quietly dropped down by slipping the two bolts back. This device prevents all spring motion of the mattress.

Arnold Knapp (p. c.) does not advise an amphitheater in the operating room, as not more than six visitors are able to see what is going on. Railings answer every purpose to keep back the spectators. He performs all operations on a specially designed operating chair which is moved into the room in which the patient is operated upon. He claims that the chair has this advantage, that often dur-

ing an operation the light has to be changed and then the chair can be more easily moved, and as it can be taken to the patient's room without difficulty there is a minimum disturbance of the patient.

Frank Todd (p. c.) has two operating rooms in his hospital, one for clean and one for septic cases. The operating room is tiled and besides the side light he has a large, slanting, opaque glass skylight which extends level with the operating table. He prefers a south exposure as it gives sufficient light in the darkest days, although it has the disadvantage of being too warm in summer. This is not a serious objection as eye operations are of short duration. To shut off too much light he uses a curtain on the outside which can be rolled over the glass.

All cataract cases are operated upon in the operating room in a specially constructed bed which has a low foot-board and large, rubber-tired wheels so arranged that the bed may be raised or lowered. There is no specially constructed amphitheater in the operating room, but there is a place under the skylight which is raised about a foot from

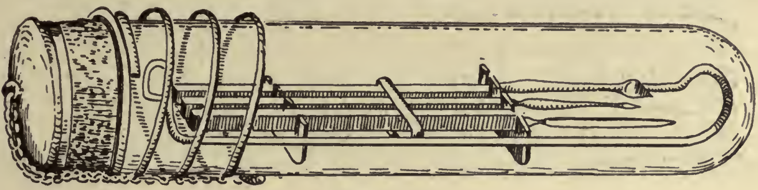

Fig. 202.
Ophthalmic Knife Sterilizer (Grosse).

the floor, where from six to a dozen may witness an operation. Contact of the spectators with the table is prevented by a nickel-plated railing.

Derrick T. Vail uses a specially constructed operating table which he prefers to a bed. He always performs an operation, where the eyeball is to be opened, in the patient's bedroom, and for light uses a Sachs' illuminator. He thinks amphitheaters have no place in an operating room and very few, if any, outsiders should be allowed to witness an operation.

Hospital Stretchers for Ophthalmic Patients.

In all cases where it is desirable or necessary to have the patient carried to his bed and deposited there with the minimum amount of disturbance, one may employ a *detachable stretcher,* an example of which is immediately described. Such a convenience has been found to answer admirably the purpose for which it was designed.

This device [Gordon Byers (p. c.)] is made up of seven different pieces:—Two pieces of heavy white canvas, five and a half feet

long by one foot wide; two side bars of oak, seven feet long, one and three-quarters by one and a half inches in size, provided with handles; two end iron rods, two feet long, with rings at the end of each and a thumb screw passing down through the iron rings; one strap eight feet long by three-quarters of an inch wide. The canvas is stitched over upon itself on the outer edges so as to make a loop through which the wooden side bars pass. The inner edges of the canvas are dovetailed so as to fit the one side into the other; and they are also stitched over upon themselves so as to form loops through which the long strap passes and binds the two pieces of canvas together as one piece. The iron rods with the rings at each end are the same length as the complete width of the stretcher, and keep it taut when placed in position by passing the rings over the ends of the side bars, where they are held in place by the thumb screws.

Fig. 203.
Detachable Stretcher for Conveying Patients to the Wards or to their Rooms from the Operating Theatre.

The stretcher is placed upon the table before the patient mounts upon it; and, following the operation, when the carrier containing the patient has been placed upon the bed, it is removed from beneath by disengaging the transverse bars, pulling out the lateral carriers, and extricating the central strap which unites the two halves.

OPHTHALMIC WARDS IN GENERAL HOSPITALS.

The great majority of ophthalmologists have not the opportunities that are offered by a hospital devoted entirely to their line of work and are consequently compelled to send their cases and do their operative, and especially their private operative, work in a general hospital.

In the general hospital the surroundings as well as equipment are not adapted for the care of ophthalmic patients unless some special provision has been made for their needs. In most general hospitals the eye department plays but an inconspicuous part. It is always ad-

visable, when possible and when there are sufficient patients to warrant it, to have this class of cases in a section of the hospital by themselves. The wards need not be large; in fact it is preferable that each ward should contain very few beds. The operative cases should be kept entirely separate from the other patients, especially those of a contagious nature. The operating room should be used solely for eye surgery. It need not be large nor require the same amount of natural illumination as is desirable in a general operating room, but it should be equipped with the various features for obtaining the best of artificial illumination—a more important requisite than daylight. The same may be said of the light equipment in the wards where subdued light is to be desired, portable lamps of one kind or another being depended upon for illumination during examination and the application of dressings.

Some ophthalmic surgeons prefer to operate in the ward or private room, claiming that there is less danger of accidents while moving the patient from the operating room to the ward. Others go further and insist in performing the operation, especially where the eyeball is opened, without moving the patient from the bed. In such cases specially constructed operating tables are used which are easily movable from room to room and take up as little space as possible. For the same purpose beds are constructed that may be raised or lowered to suit the requirements of the operator. These have removable head and foot pieces, so that there is no obstruction about the field of operation.

Trained House Surgeons.

One of the most important requisites of an eye service in a general hospital are house surgeons or internes *trained in ophthalmic work.* One or two of the House Staff should be assigned to duty in the eye department and should be held primarily responsible for the work of the department.

The Ophthalmic Nurse.

The wards should be in charge of a permanent head nurse, with one or two assistant nurses. When it is not possible to have a permanent nurse one should be carefully selected from the other nurses and her time of service should not be less than three months, more if possible. She should devote her whole time to the service.

The duty of the ophthalmic nurse is to perform, personally, all the nursing necessary in her department. The nurse having charge of the contagious cases should under no circumstances come in contact with the operative cases for obvious reasons. She should always be on hand to make the rounds with the attending surgeon and the in-

terne surgeon, and should carry with her a tray upon which is placed everything necessary for the daily dressing of the patients. She should not run here and there to get this bandage or that solution, but should remember that time is valuable and that everything must be close at hand. She should be able to vouch for the cleanliness, sterility and freshness of everything upon her tray and should give this matter her personal and earnest attention, remembering that while in general surgery a little suppuration in a wound need not necessarily prove disastrous, in ophthalmic surgery, particularly in cataract operations and iridectomies, perfect healing must be secured and the slightest infection will almost certainly bring ruin in its train. She

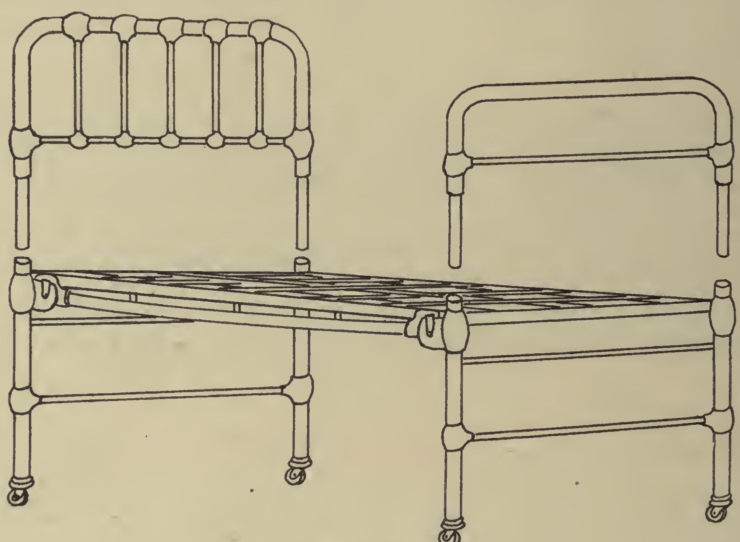

Fig. 204.
Aseptic Hospital Bed.

should learn the knack of putting solutions and ointments into the conjunctival sac, and irrigating or cleansing the eye without injuring it, and of properly adjusting a bandage. She should understand how to use hot and cold applications; these and many other things too numerous to mention and so trifling as to appear insignificant and yet of great importance if the best results are to be obtained.

In the intervals between the visits of the attending surgeon the ophthalmic nurse should faithfully follow out his instructions, such as putting medicines in the eye, changing bandages, cleansing eyes, etc. She should so attend to her duties that she will inspire the attending surgeon with confidence that her duties are well and faithfully performed.

The ophthalmic nurse should also attend the surgeon when he performs operations. She should prepare the patient for operation and should have all dressings ready for application after the operation. Her duties are only second in importance to those of the surgeon.

A week or ten days before the nurse goes off duty the oncoming nurse should be assigned to the department, to make the rounds with both the attending surgeon and the retiring ophthalmic nurse, for by so doing she becomes familiar with the work and the establishment of new relations is accomplished with the least friction to all parties concerned.

One great advantage in the teaching of ophthalmic nurses in this

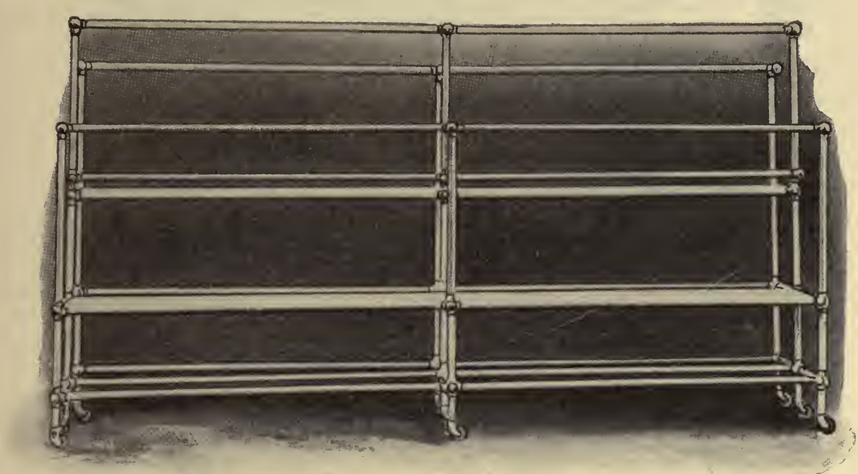

Fig. 205.
Observation Stand for Witnessing Ophthalmic Operations. Accommodation for Eight Spectators.

way is the education of women in this line of work, so that after graduating surgeons can secure their services in private cases treated at home.

Amphitheater Operations.

Operations in an amphitheater present advantages which to some extent offset the risks attendant upon removal of the patient after operation from the operating room to his bed. A well-kept operating room needs, for example, very little extra preparation; it is aseptic; everything is handy and convenient for instruments, dressings and all appliances necessary for operative work. Moreover, when trained assistants do the work there is a minimum of danger from accidents

during the removal of the patient from the operating room to the ward.

Sterilizers and Sterilizing.

A complete sterilizing outfit for an ophthalmic operating room should consist of:—

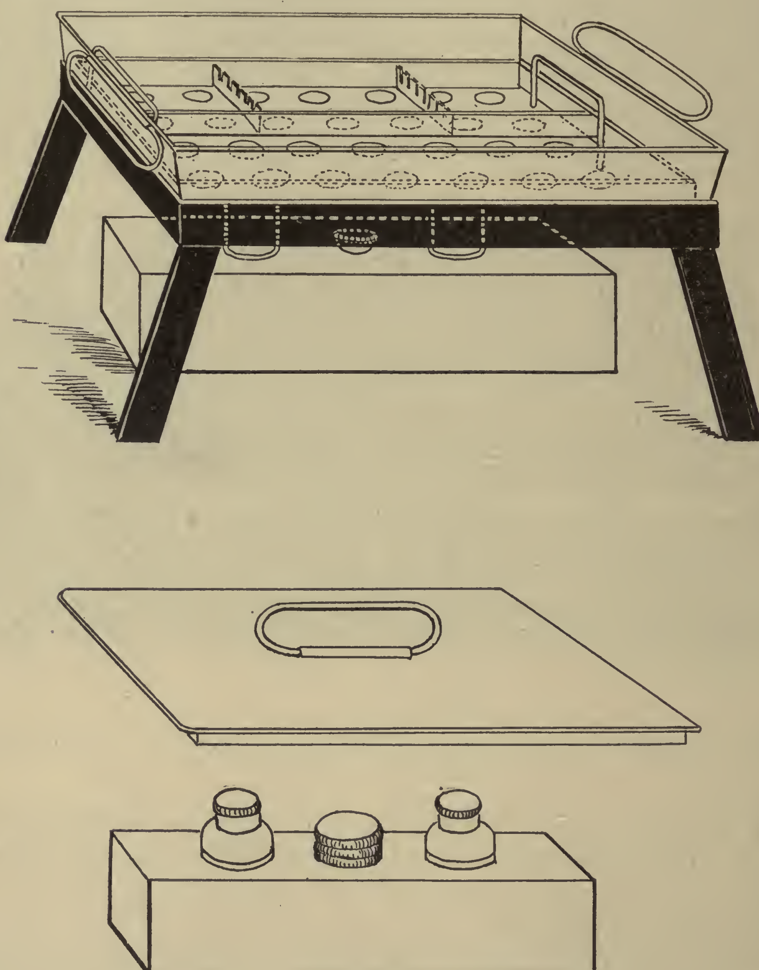

Fig. 206.
Portable Sterilizer for Eye Instruments (Veasey).

(1) An Instrument Sterilizer;
(2) A Dressing Sterilizer;
(3) A Water Sterilizer;
(4) A Sterilizer for pans, basins, irrigators, etc.

Instrument Sterilizer.

The boiling of such instruments as knives in water is recognized as the most satisfactory as well as the safest and simplest method of sterilization. Sodium carbonate or borax (2 per cent.) added to the water will protect the instruments against oxidization. The instruments are placed in a perforated tray with removable handle and placed in the receptacle containing the water which is then brought to a boil, and the procedure continued for at least twenty minutes.

Sterilizers for instruments are common to all hospitals. They are usually made of highly polished or nickel-plated brass or copper. They can be equipped with steam heating coils connected with the steam supply of the building, or they may be furnished with either elec-

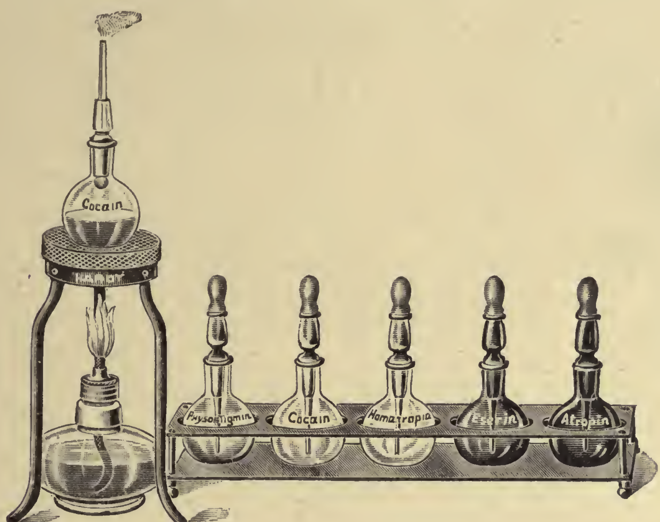

Fig. 207.
Strocheim Apparatus for Sterilizing Ophthalmic Solutions.

tric, gas, petroleum or alcohol heating attachments. A detailed description of the large sterilizers employed in special and general hospitals is hardly in place here.

Clarence A. Veasey* describes a new *portable sterilizer* for eye instruments. It is very compact and at the same time sufficiently large for all the instruments employed in the ordinary ophthalmic operations.

The sterilizing pan is five inches wide, seven inches long and one and three-fourth inches deep, with a handle at each end and a closely-fitting cover to prevent the escape of steam. Inside of this is a perforated tray with handles for lifting, containing on one side a movable rack for the more delicate instruments. This tray rests upon small buttons in the bot-

*Veasey. *Ophthalmic Record*, Vol. IX, 1900, page 80.

tom of the pan, allowing a free circulation of the water when boiling and preventing that injury which usually occurs to instruments when placed directly upon the bottom of a heated dish. The whole rests upon a skeleton stand, which, when not in use, is folded and fits tightly around the side of the pan. One of the best features of the sterilizer is the alcohol lamp. It is six inches long, one and one-fourth inches wide and one and one-eighth inches deep; has two large burners which bring water to the boiling point in five minutes and holds sufficient alcohol to keep it boiling for nearly two hours.

All *cutting instruments should be boiled the minimum length of time in order to guard against injury to their edges.* In order to avoid this knives may be sterilized by subjecting them to chemical sterilization. This may be accomplished by placing the knives in a tray containing 90 per cent. solution of carbolic acid with glycerine

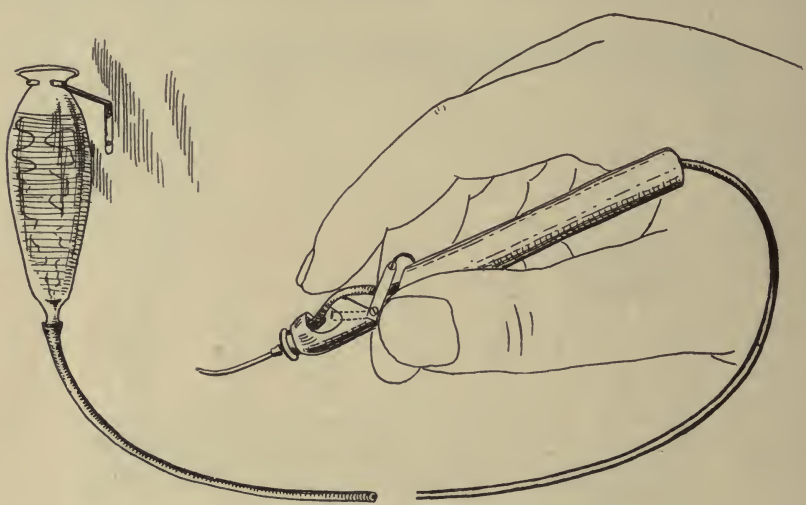

Fig. 208.

Anterior Chamber Irrigator for Ophthalmic Operating Room (Lippincott.)

where allowed to remain for fifteen or twenty miutes, and after removal immersed in very hot water or 80 per cent. alcohol for the purpose of washing off the carbolic acid; then thoroughly dried with a sterilized towel. Exposing the knives to the fumes of formaldehyde is an effective method of sterilization. Formaldehyde gas is a powerful germicide, is readily diffused, has great powers of penetration, and quickly destroys all forms of micro-organisms.

H. O. Reik*, of Baltimore, describes a formalin sterilizer made of copper.

It measures 7x12x12 inches, and has an air space of a little more than 1,000 cubic inches. The shelves are of heavy wide-meshed wire gauze, the

*The Sterilization of Instruments with Formaldehyde, *Phila. Med. Jour.*, Feb. 4th, 1899.

upper one extending entirely across the chamber, while the lower two are only eight inches long, extending from the right side to an upright standard four inches from the left wall, thus leaving a space four inches wide by eight inches high, which is reserved for vaporizing the pastils. There

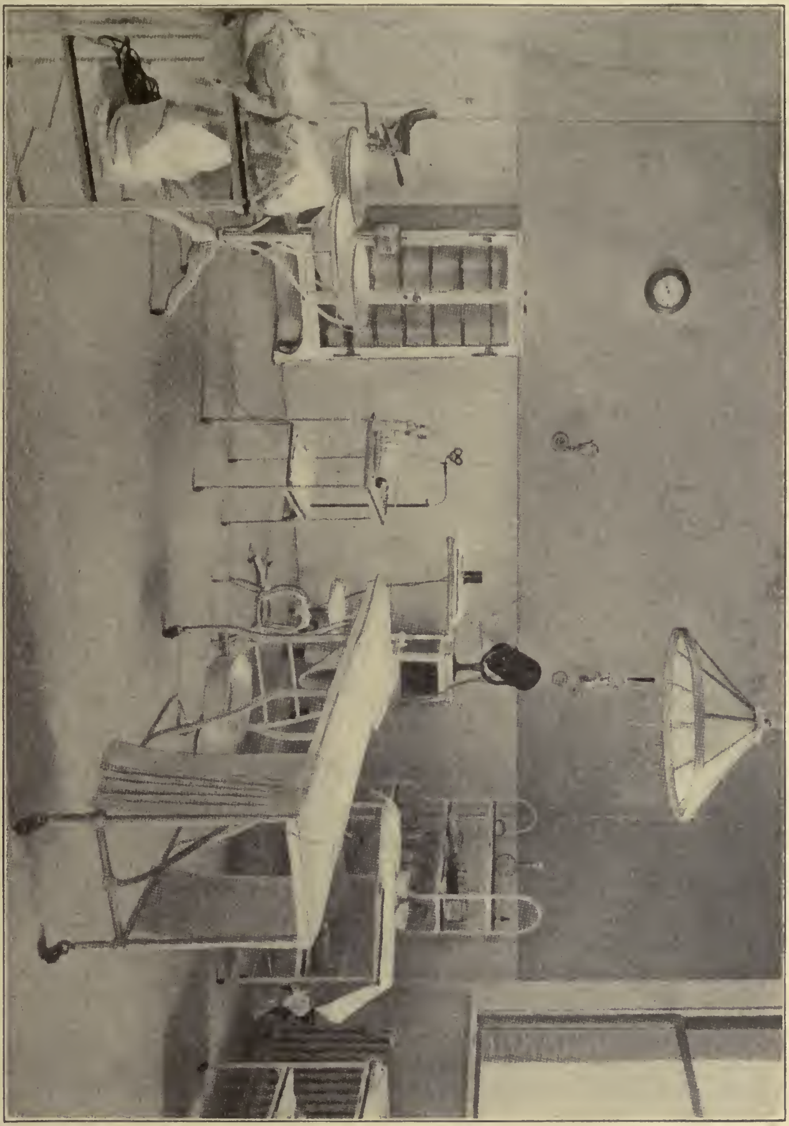

Fig. 209.
Eye Operating Room. Manhattan Eye, Ear & Throat Hospital.

is a small tray for carrying such instruments as cataract knives so as to prevent their cutting edges from coming into contact with anything. The sterilizer, when closed, must be air-tight, for if an interchange of gas and air is permitted the gas is diluted and fails to produce the expected results.

Dressing Sterilizer.

The dressings, etc., are brought in direct contact with steam by

placing them in chambers or cylinders and subjecting them to a pressure of superheated steam at 212° F. (100° C.) for twenty or thirty minutes. This produces thorough asepsis. Of the various methods of using steam for sterilization purposes that at high pressure is the most efficacious and it is generally used in all hospitals.

The autoclave is a form of high pressure sterilizer used principally by the French. It is used for the sterilization of both dressings and instruments. It consists of a boiler with inlet and outlet pipes surrounded with a jacket. The pipes are so adjusted that steam under any desired pressure may be admitted to the sterilizing chamber. Entrance to this chamber is effected by means of a cover or door, securely held in position by strong clamps, and provided with a registering gauge and steam valve..

Water Sterilizer.

Water to be absolutely sterile should be boiled at a temperature of not less than 250° F. for twenty minutes.

Sterilizers for Pans and Other Utensils.

Sterilization of pitchers, pans, irrigators and all utensils used during an operation may be accomplished by placing them in a receptacle which has connection, by means of coils, with the steam boiler; or they may be submerged in water in a similar receptacle or boiler and the water heated to the boiling point from which the steam is generated. The source of heat may be gas, petroleum or electricity. The utensils may also be immersed in a trough containing such strong antiseptic solutions as corrosive sublimate, lysol, carbolic acid, etc.

The Furniture of Ophthalmic Operating Rooms.

In the Manhattan Eye, Ear and Throat Hospital the ophthalmic operating room is 16 by 18 feet, with a tile floor and tile base 5 feet high on the walls. The walls above the tiling and ceiling are painted light ivory and enameled; the windows are on the north side, on which are dark shades drawn during cataract operations, artificial light then being used exclusively.

There is no skylight. In connection with this room there is a "wash-up" room for surgeons with three sets of bowls, a small room with supply closets, etc., and a sterilizing room which is equipped like the corresponding room in a general hospital, i. e., with dressing-sterilizer, water-sterilizer and utensil-sterilizer. In the operating room are an ophthalmic operating table designed by Emil Gruening, an instrument cabinet, a cabinet for solution-bottles and other small articles, wall stand with four glass shelves for dressings, four glass top tables, stand with three basins for hand solution, one adjustable table for holding instruments, two white enameled stools, one two-step stool to

enable patients to get on the operating table, one Haab magnet placed on a movable stand, small portable motor for cautery purposes, small gas sterilizer for instruments and a cluster of electric lights over the operating table provided with a steel-enameled hood over the lamps, from which, also, is a connection for a hand lamp.

All operations are performed on an operating table and the patients taken on a wheel-stretcher to their rooms. In operations in which the eyeball is opened there is placed on the table a canvas stretcher which is divided in the center and held in place by a long, flat, wooden pin, so that the patient can be readily moved to the wheel-stretcher. After being placed in bed the canvas is removed from under the patient by slipping out the wooden pin and allowing it to separate in the center.

The Ophthalmic Operating Table.

The *operating table* should be of simple construction. The frame-work should be made of steel, mounted upon castors and capable of being moved to any part of the operating room without effort. The top should be of glass with or without an adjustable head-rest, some surgeons preferring the latter to assist in keeping the patient's head steady. The metal parts should be highly polished, or painted smooth with a thick coating of enamel paint, so that it can be scrubbed and sterilized without difficulty and without danger of rusting. Although any table that is used for general surgical work will answer the purpose, a number of tables have been specially constructed for ophthalmic surgery, their designers claiming certain advantages over the general surgical chair for this class of work.

A table designed by Charles H. May is made of steel and can easily be converted from an examining chair into an operating table.

The center section or seat can be raised and lowered by means of a crank and endless screw, so that it always remains in a horizontal position. The head section or back is hinged at the junction with the seat and may be adjusted at any angle from the horizontal position upward. The foot section is hinged to the seat in a like manner and is capable of adjustment to any angle from the horizontal downwards. The table or chair is supplied with an adjustable head-rest that may be raised and lowered, moved forward or backward or inclined at various angles. It has two side pieces adjustable to any width, which can be turned back out of the way when not in use. A swinging glass tray for holding instruments, etc., is also provided and this may be attached to either side of the chair. Cushions add to the height.

L. Webster Fox uses a table for operating which consists of a brass frame mounted upon four legs, every one of which is provided with castors (locked if necessary) to facilitate movement from place to place.

Suitable braces are placed at each angle to render the frame-work firm and durable. The frame is made of rather thin, highly polished brass

tubing, thus giving the entire table a neat appearance, a feature ignored in most tables. The height of the table is four and one-half feet, the width one and one-half feet and the length six feet. The top of the frame is covered by a single piece of thick plate glass, out of the left side of which, near the head of the table, a semi-circle is cut to enable the surgeon to stand more directly in front of the patient's face. A corresponding curve is made in the frame work in this locality. A head-rest of metal and glass is provided which is raised or lowered to suit the convenience of the operator. The upper rim of the head-rest is longer on its under surface for

Fig. 210.

The Webster Fox Operating Table.

receiving the extremities of the head clamps. These clamps are two long, thin, flat pieces of metal, one end of which is heavy, thick and grooved to fit snugly over the tongue of the head-rest. The clamps are made to slide along the rim of the head-rest until close to the patient's head, any movement of which will cause them to bend upon the rim and become more firmly fixed. A detachable leaflet for holding an instrument tray and dressings is also provided for one side of the table.

PART IV.

CHAPTER I.

OPERATIONS FOR ENUCLEATION OF THE EYE AND THEIR SUBSTITUTES.

By FRANK ALLPORT, M. D., Chicago.

Introductory—What Eyeballs shall we Remove?—Enucleation and Panophthalmitis—Evisceration versus Enucleation—Causes of Sympathetic Ophthalmia after Evisceration—The Anesthetic to be Employed in Excision of the Eyeball—Eyeball Removals and the Substitutes for such Operations—Enucleation—Preparation of the Patient and Surgeon for Enucleation—The Ferrall or Bonnet Operation—Enucleation of Collapsed Globes—Post-Operative Treatment of Simple Enucleation—Suture of the Wound Margins after Enucleation—Allport's Operation—The Vienna Method of Enucleation—Arlt's Method of Enucleation—Abscission and Evisceration (Exenteration of the Eye)—Objections to Abscission—Final State of the Eyeball after Evisceration—The Operation of Evisceration—Cautery Methods in Evisceration—The Operation of Abscission—Mules' Operation—Prothesis in Mules' Operation—Drawbacks of Mules' Operation—The Use of Paraffin in Mules' Operation—Other Substitutes for the Glass Ball in Mules' Operation—The Frost-Lang and Morton-Oliver Operations—The Operation for Delayed Implantation—Optico-Ciliary Neurotomy or Neurectomy—The Operation of Optico-Ciliary Neurotomy—The Transplantation of Animals' Eyes into Human Sockets—Gifford's Operation for Sightless Stumps—Indications for Removal of the Eyeball—Artificial Eyes.

The removal of an eyeball is a serious major operation and should be undertaken only when the surgeon is sincerely convinced of its necessity and wisdom. It should never be forgotten that the exsection of an eye not only destroys one-half of an individual's visual prospects, but produces a deformed and repulsive physical condition most mortifying to the patient and distressing to his friends.

While eyes are frequently lost from non-traumatic causes, it nevertheless happens that *the necessity for eyeball removals often follows in the wake of an accident,* and inasmuch as most serious traumas occur to laboring men, it transpires that a large proportion of such operations are performed upon this class of people. Almost

all corporations at the present time either employ surgeons to care for their injured employes, or are protected by some form of accident insurance. It, therefore, usually happens that men with injured eyes are cared for promptly by a Company Surgeon, who endeavors to place the eye in the most favorable condition to be saved. This is done not only in the interests of the patient, who should be given every opportunity for ocular salvation, but also to protect the company from personal-injury litigation, as law suits or threats of law suits are extremely liable to follow all forms of bodily accidents. The laudable desire (under these circumstances) to save eyesight or at least a sightless eye, sometimes leads the surgeon into the error of endeavoring to rescue an eye that is manifestly lost at the beginning of the case. It is difficult for the surgeon to forget that the amount of his company's legal responsibility may be based on the amount of manifest injury the patient has received, and that some portions of an eyeball saved will appear better to a jury than if a complete enucleation has been performed. Let is not be understood that I deprecate any reasonable effort toward ocular salvation, for this is not the case. I merely wish to remind the surgeon that some eyes are primarily so badly damaged that any effort at their preservation is worse than useless; and, therefore, such a course is bad practice and is sometimes followed by the loss of the other eye from sympathetic ophthalmia. Instances of this nature are very liable to occur when steel fragments have been driven into the eye and have been removed by a magnet.

What Eyeballs shall we Remove?

As a rule it is not wise to undertake the preservation of an eye into which a very large piece of steel has been driven and the ocular laceration is excessive. The magnet may remove the steel, but no useful result has then been accomplished, as almost invariably either speedy panophthalmitis develops or a protracted uveitis ensues, followed by a shrunken, painful, deformed, sightless and dangerous eye that will be, or at least should be, removed in order to afford the patient comfort and safety. Meanwhile much time has been lost and considerable useless expense incurred, and after perhaps weeks of effort the eye is then removed, a procedure which, perhaps, should have been accomplished immediately after the accident. A manifestly destroyed eye should be removed at once, disregarding all professional pride in the attempt to save the globe and all desires to placate the feelings of the patient or his friends. The patient much more readily consents to an eyeball removal immediately after the accident than when some weeks have transpired and he still has an eye which,

though shrunken, sightless, irritable and dangerous, is yet one from which he can hardly be persuaded to part. The surgeon, on the other hand, after weeks or months of effort, hesitates to acknowledge defeat by advising an eyeball enucleation and thus the patient perhaps remains possessed of an apologetic eyeball, which is a constant care and menace, and from which he should have been separated at the beginning. There can be no doubt that while the magnet has accomplished much good, and has preserved many useful eyes, it has increased the number of cases of sympathetic ophthalmia by encouraging the efforts at eyeball preservation in unsuitable cases. For this the magnet is in no way to blame, however, as the fault lies with the surgeon whose optimistic tendencies persuade him to undertake the accomplishment of an apparently unfeasible proposition.

The usefulness of an eye is confined to two purposes, viz., vision and beauty, and when through accident or disease both of these attributes are lost, and in addition an element of danger is added, the eye should be removed.

Again I wish to protest against being misunderstood as advocating the too frequent removal of eyeballs, my desire being merely to protest against ill-advised and dangerous efforts along the line of ocular salvation.

The best judgment of well-ripened experience is sometimes taxed in advising a course of action subsequent to an ocular trauma and it should be remembered, notwithstanding what has just been said, that many good eyes and considerable useful vision not infrequently follow the wise and conservative care of such cases. Scleral ruptures are not as unfortunate as severe injuries in the anterior portion of the eye, and a globe in which a pure scleral injury has occurred should be conservatively watched before enucleation is advised. It is frequently difficult to judge as to the advisability of eyeball removals and a decision should be reached by experience, judgment, the probability of primary infection and the extent and location of the injury, it being remembered that *traumas in the ciliary region are more dangerous than those inflicted in other regions,* although this statement has been called in question by several recent writers.

It sometimes becomes necessary to remove eyeballs for conditions that are practically non-traumatic in their origin, such as in the various infections, tumors, staphyloma, hydrophthalmos, glaucoma, atrophied and irritable globes, corneal ulcerations and their sequelæ, iritis, panophthalmitis, sympathetic ophthalmia, operative infections, etc. It must not be understood that all of these conditions *invariably* require some form of eyeball removal, but each of these diseases may become so intense and aggravated in character as to demand the

execution of some variety of this surgical procedure. Some of these conditions, such as operative infections, traumatic panophthalmitis and corneal ulcerations (if produced from some accident such as a foreign body lodging in the cornea, etc.) should, strictly speaking, be classified as injuries, but I have taken the liberty of considering them differently for purposes of convenience.

It may be said in a general way that all eyeballs permanently bereft of vision, that are persistently inflamed, painful and irritable, should be removed. Concerning tumors, it may be said that almost all cases of intra-ocular tumors call for eyeball removal, remembering, however, that syphilitic growths can usually be dissipated by proper treatment. Orbital tumors generally demand eyeball enucleation, unless they can be removed from the side of the eye, or by some such operation as that recommended by Krönlein.

Enucleation and Panophthalmitis.

The question of the *removal of an eye by enucleation during an attack of panophthalmitis* is as yet unsettled. Some observers are opposed to such a procedure, while others believe it justifiable, unless the infection and swelling are most excessive. I have enucleated many eyes in the presence of various grades of panophthalmitis and have never had cause to regret it. It is a significant fact that out of 10,734 cases of simple enucleation collected from the reports of the Oph. Soc. U. K.,[1] there occurred only 7 cases of fatal meningitis. All of these 7 cases were instances of suppurative panophthalmitis, but it cannot be proven that the enucleation caused all the deaths; they might have occurred without operative interference, as instanced by a case reported by Webster in the Transactions of the Medical Society of the State of New York for 1888. Becker claimed in 1888 that only 43 cases of meningitis after enucleation had ever been placed on record. There can be no doubt that while meningitis, thrombo-phlebitis and orbital abscess may follow the enucleation of a panophthalmitic eye, the risk is exceedingly small and that many operators of large experience have never seen such a case. The writings and statistics of Andrews[2], Pooley,[3] H. Knapp,[4] Becker,[5] Noyes,[6] Brudenell Carter, McHardy, Gunn, Panas, Dufour, Motais, Gayet and

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[1]*Trans. Oph. Soc. of U. K.*, 1898, p. 239.

[2]Joseph A. Andrews. Enucleation of the Eyeball During Purulent Pan-Ophthalmitis. *New York Medical Journal*, Dec. 29, 1888, Vol. 48, p. 701.

[3]T. R. Pooley. Two Cases of Enucleation. *Annals of Ophthal.*, 1897, p. 243.

[4]Norris and Oliver. *System of Diseases of the Eye.* Vol. 3, p. 887.

[5]O. Becker. *Die Universitätsaugenklinik zu Heidelberg*, 1888.

[6]H. D. Noyes. Enucleation During Panophthalmitis. *Trans. Amer. Ophthal. Soc.*, 1888 and 1889, p. 314.

others are strong arguments in favor of the practical safety of this procedure.

The cutting of the optic nerve, however, during an enucleation which is accompanied by panophthalmitis surely opens up a pathway of infection from the eye to the brain, a surgical fact which no one can afford to ignore, and numerous instances can be found in ophthalmic literature testifying to *the occurrence of fatal meningitis after enucleation performed in the presence of panophthalmitis.* Such instances may be found in the writings of Graefe,[7] Nettleship,[8] Coppez, Panas,[9] Hobby,[10] Delibes,[11] Risley,[12] Siffre,[13] Enslin,[14] Kuwahara[15] Higgins, Mules, Lapersonne, Meyer, Galezowski, Abadie and others. Nettleship[16] and others have recorded cases of thombosis of the cavernous sinus following enucleations. Nor is meningitis the only serious consequence that may follow enucleation during panophthalmitis, for, contrary to the belief entertained by some surgeons that sympathetic inflammation of the opposite eye does not follow panophthalmitis in the other, Ahlstrom, Schirmer[17] and Würdemann have reported cases where this unfortunate termination has occurred. These cases seem to contradict the theory of Leber and Deutschmann[18] that the panophthalmitic inflammation plugs up the lymph passages and prevents germ migration, also the theory of Gifford[19] that the infiltration of pus corpuscles in the optic nerve lymph spaces prevents bacterial invasion of the sound eye.

When the extreme rarity (only one case in 1,596 cases at Moorfields'[20]) of the occurrence of sympathetic ophthalmia after enuclea-

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[7]Alfred Graefe. *Trans. Internat. Oph. Congress*, 1900, Committee Report.

[8]E. Nettleship. On a Case of Meningitis After Excision. *Trans. Oph. Soc. of U. K.*, 1886, p. 445.

[9]P. Panas. Total Combined Keratectomy. *Arch. d'Ophtal.*, Vol. 18, No. 9, 1898.

[10]C. M. Hobby. Enucleation in Panophthalmitis. *Amer. Jour. of Ophthal.*, 1886, p. 141.

[11]P. Delibès. A Case of Death Following Enucleation. *La Clinique Ophtal.*, July 25, 1898.

[12]S. D. Risley. Panophthalmitis. Fatal Meningitis Following Enucleation. *Jour. Amer. Med. Assn.*, Oct. 21, 1893, p. 298.

[13]Siffre. Thesis of 1889. Rohmer. La resection du nerf optique après le procédè de M. de Wecker dans l'Ophtalmie Sympathique. *Annales d'Oculist*, April, 1892, p. 249.

[14]E. Enslin. *Arch. f. Augenheil.*, Sept., 1904.

[15]Kuwahara. *Arch. f. Augenheil.*, Sept., 1904.

[16]E. Nettleship. On a Case of Meningitis After Excision of the Eyeball. *Trans. Oph. Soc. of U. K.*, 1886, Vol. 6, p. 445.

[17]O. Schirmer. Sympatische Augenerkrankung. *Graefe-Saemisch Handbuch*, 1900, 23-25.

[18]T. Leber and R. Deutschmann. Ueber eitrige Meningitis nach Enucleatio Bulbi. *Graefe's Arch. f. Ophthal.* Also *Arch. f. Ophthal.*, 1885, Vol. 4, p. 251.

[19]H. Gifford. Clinical and Pathological Notes on Sympathetic Ophthalmia. *Jour. Amer. Med. Assn.*, Feb. 10, 1900. Also A Contribution to the Study of Sympathetic Ophthalmia. *Arch. of Ophthal.*, Vol. 15, No. 3, 1886.

[20]*Trans. Oph. Soc. of U. K.*, 1898, p. 243.

tion is considered, as compared with other forms of eyeball removal, the question may well be raised as to whether, all things considered, enucleation is not the safest operation. In most cases of both meningitis and sympathetic ophthalmia, following any form of eyeball removal, it is difficult to establish the fact of connection. The causative factor may have passed beyond the eyeball and into the connecting tract before the operation was performed, in which case the disease will occur after the operation, which will frequently be erroneously accused of precipitating the disaster. In the event of sympathetic ophthalmia occurring after an eyeball removal, for instance, it is quite well conceded that it is only when the disease appears within from about three to four weeks* after the operation that the latter should be accused of producing the sympathetic ophthalmia, and even then the guilty connection may be difficult to establish.

It is a statement which is justified by a careful inspection of recorded cases, that a vast majority of instances of meningitis and sympathetic ophthalmia, following any form of eyeball removal, have happened in cases where there could have been a well-grounded suspicion that these diseases would have occurred if no operation whatever had been performed. It would be difficult indeed to establish the fact that any particular method of eyeball removal is especially prone to produce either meningitis or sympathetic ophthalmia; and it would be equally difficult to prove that any method is conspicuously exempt from disastrous consequences. Each operation has its friends and its foes, its advantages and disadvantages, and while some form of enucleation is performed more than any other method of operation, yet many other procedures have their places in ophthalmic surgery, and the wisest surgeon is he who can and does utilize the various operations under circumstances best adapted for their use.

Evisceration versus Enucleation.

Practically all the eyeball removal operations that have been devised since the Ferrall or Bonnet operation have originated in a desire to lessen deformity, and avoid meningitis or sympathetic ophthalmia. It was largely, for instance, the fear of severing the optic nerve during an attack of panophthalmitis and opening an infective communication with the brain that induced the operation of evisceration. Coupled with this idea was the conviction that inasmuch as the sclera and muscles were left intact, a large, movable stump would result and that therefore a prominent, mobile, artificial

**Sympathetic ophthalmia rarely occurs in the first month after an injury,* very rarely in the second and third month, *most frequently in the fourth and fifth months,* and then more and more rarely during the succeeding months and years of life.

eye would materially mitigate the deformity. It is still felt by many observers that evisceration is safer than enucleation in panophthalmitis, but only a few surgeons hold to the belief that it affords a better or more mobile stump than is obtained after a well-executed enucleation, especially where muscular power is retained by some method of suturing the muscles together. While *the stump after evisceration is primarily movable and prominent, these qualities are ultimately largely lost,* owing to the inevitable scleral atrophy and retraction of the ocular tissues into the posterior portion of the socket. Comparative measurements of rotation as between enucleation and evisceration, as compiled by Hotz,[21] Truc[22] and de Schweinitz,[23] demonstrate the truth of this statement. Besides this, notwithstanding the statements of such observers as Gifford,[24] Henderson[25] and others, who feel that inasmuch as the optic and ciliary nerves are not cut the danger of sympathetic ophthalmia is lessened, there is an impression in ophthalmological circles that sympathetic ophthalmia is more apt to follow evisceration than enucleation. In this connection I take the liberty of quoting a portion of an address delivered by Henderson in 1906 before the St. Louis Ophthalmological Society in which he states in a remarkably clear, consecutive and concise manner the evolution of thought concerning the etiology of sympathetic ophthalmia ;—

"First came the theory of Mackenzie that the inflammation of the retina was propagated along the optic nerves to the retina of the sympathizing eye. Next came Tavignol and Heinrich Mueller who found the ciliary nerves to be the channels of communication. Gifford says, 'To Alt belongs the credit of the first pathological evidence in favor of the transmission of sympathetic ophthalmia through the optic nerves.' I believe this work was done by Alt as early as 1876. Then came Horner and Knies with a revival of the optic nerve theory of Mackenzie, in 1879, followed in 1881 by Snellen, Berlin and Leber, who maintained that the inflammation was parasitic in origin. Snellen held that the disease was transmitted from one choroid to the other through the lymph spaces of the optic nerves. Berlin thought the medium of communication to be the general circulation and Leber contended for the optic nerve route. Next in the procession is Deutschmann with his experiments, which proved to the satisfaction of many that the disease is due to the transmission of bacteria along the optic nerves and their sheaths. In 1884 Alt's experiments led him to a conclusion similar to Deutschmann, and it was at this time, before Gifford, Bellarminoff, Selenkowsky and Rosenmeyer came forward with their toxin theories, that 'Alt gave the first experimental proof that a soluble organic poison (*abrus precatorius*) when injected into a rabbit's eye could travel, by way of the optic nerves and their sheaths, to the other eye and there produce symptoms of sympathetic ophthalmia.' Gifford in 1886 inclined to the belief that the disease was infectious. He thinks the path of communi-

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[21]F. C. Hotz. Internat. Oph. Congress, 1900.

[22]H. Truc. Internat. Oph. Congress, 1900.

[23]G. E. de Schweinitz. Internat. Congress, 1900.

[24]H. Gifford. (Henderson). Evisceration or Enucleation? *Trans. St. Louis Ophthal. Soc.*, 1906.

[25]F. L. Henderson. Evisceration or Enucleation? *Trans. St. Louis Ophthal. Soc.*, 1906.

cation 'leaves the optic nerve with the vessels, passes through the orbit into the cranial cavity and thence via the subvaginal to the supra-choroidal space of the second eye.' At the Heidelberg Congress of 1891, Schmidt-Rimpler proposed a modified ciliary nerve theory. This conception, which I believe was also held by Panas and Bach, is that irritation of the ciliary nerves renders the second eye more susceptible to the influence of poisonous elements which are introduced through some other channel. Then Mazza, Randolph, Limbourg and Levy, Schirmer, Greeff, Ulrich and Bach failed to confirm by experimentation the Deutschmann theory.

Next we have the toxin theories of Bellarminoff, Selenkowsky and zur Nedden, and the cytotoxin suggestion of Brown Pusey in 1903. In 1904 Theobald restated his belief in the ciliary nerve theory. In 1905 Motais contended for the venous channels as the source of communication. In the same year Raehlmann suggested the infecting element to be an ultra-microscopic body. Ruge teaches that the disease in the primary eye is a fibrino-plastic uveitis and Fuchs' claims it to be a proliferative uveitis—a proliferation of epitheloid cells in clusters or singly within the confines of the uvea. Fuchs is seconded by E. V. L. Brown.

In 1906 Golovine holds to the Brown Pusey cytotoxin theory. Fuchs inclines to metastasis as the means of communication and Roemer suggests an invisible micro-organism, which passes through the blood, is pathogenic for the eye and indifferent for the rest of the body. Roemer also declares a disposition to the development of sympathetic ophthalmia cannot be brought about by irritation of the ciliary nerves of the first eye. All of which goes to show that we do not know what causes sympathetic ophthalmia or how the unknown cause is conveyed from the exciting to the sympathizing eye.

"Whether the etiological element be a microbe, a toxin, a cytotoxin, an ultra-microscopic body, a reflex or a trophic nerve influence, or something yet to be discovered, I fail to see why the operation of evisceration will not as effectually remove it as an enucleation. Selenkowsky in studying the lymph currents found that a stain injected into one vitreous of a rabbit, reached the other in two days. If the infecting element has already passed beyond the reach of carbolic cauterization inside of the sclera, it in all probability cannot be captured by going one millimeter deeper and removing the sclera. This also seems to me to hold good regardless of the method of transmission, whether it be along the substance of the optic nerve by contiguity of tissue, by the lymph channels, the venous or arterial circulation, or the ciliary nerves. Statistics are useless in weighing the relative values of the two methods as sympathetic ophthalmia has followed both operations. Furthermore, it follows so rarely when compared with the number of these operations that the ratio is attenuated to a point which makes figures useless. The committee appointed by the Ophthalmological Society of the United Kingdom to decide which operation afforded greatest immunity from sympathetic ophthalmia, presented a report which left the question still open. Pflueger at the 13th International Congress (1900) claimed evisceration was equal to enucleation in preventing sympathetic ophthalmia when it is performed within three weeks of the injury. de Schweinitz agrees with him, fixing the same time limit. These three weeks, of course, refer to the stereotyped and arbitrary period in which we are supposed to be safe from sympathetic trouble. An evisceration leaves all the orbital tissues undisturbed and presents a clean, white, well cauterized and well drained open wound for resolution. An enucleation presents the cut ends of six muscles, the open ends of numerous arteries, veins, nerves and lymphatics, and the more or less oozing surface of Tenon's capsule. It is difficult for me to believe that the latter condition offers any greater protection than the former against the development or transmission of this unknown enemy. Gifford says, 'Evisceration is, in my opinion, the operation of choice as a prophylactic for sympathetic ophthalmia, although the weight of authority is in favor of enucleation.'"

Causes of Sympathetic Ophthalmia after Evisceration.

The element which seems to play an important part in the de-

velopment of sympathetic ophthalmia after an evisceration is the failure to cleanse thoroughly the interior of the sclera of all uveal tissue. Schieck,[26] Hotz,[27] Schmidt-Rimpler and others have reported instances of this kind. Such uveal shreds contain structures liable to produce sympathetic ophthalmia, and should be absolutely removed, and as this is difficult of attainment (as well as for other reasons) the operation has rather fallen into disfavor. It is a simpler operation than enucleation, especially when there is great infection, swelling and adhesion of the orbital tissues; but if great care is taken to eviscerate completely the ocular contents, and then to cauterize the scleral lining with carbolic acid, it would seem that it should be a reasonably safe and reliable procedure.

Nevertheless, de Schweinitz[28] narrates an interesting case in which he carefully eviscerated an eye, taking great pains to clean the interior of the scleral cup. He afterwards enucleated the same eye on account of a painful stump. A microscopical examination revealed uveal tissue that he had not removed. Waldispühl[29] records a similar case. This shows how impossible it is for even a careful and skillful operator to be sure of the thorough removal of all dangerous material. The first reports after Graefe's endorsement of evisceration were exceedingly flattering, for according to Bunge[30] in 1887, no case of death or sympathetic ophthalmia followed Graefe's first 240 cases. Shortly after this Schuleck lost two patients out of 36 eviscerations and since then enough unfortunate cases have been reported to cause many surgeons to fear this operation. H. Knapp[31] practiced evisceration until 1883, when he encountered a severe case of orbital cellulitis and thrombosis which caused him to practically abandon the operation.

The Anesthetic to Be Employed in Excision of the Eyeball.

In any form of operation for the removal of an eyeball it is best to employ a general anesthetic if possible. This subject is fully discussed elsewhere in this *System*.

Local anesthesia may be used if the patient's physical condition is such as to render it inadvisable to administer a general anesthetic, or if he is radically opposed to ether, chloroform, etc., and is willing to be brave if a local anesthetic is used. Children are not suitable subjects for local anesthesia. Bruns[32] in 1909 reported that in his clinic at New Orleans local anesthesia was used altogether, except in cases of young

[26] F. Schieck. Bietet die Exenteratio Bulbi einen hinreichenden Schutz gegen den Eintritt der Sympathischen Ophthalmie? *Bericht der Ophthal. Gesell.*, Vol. 5, 1908, p. 355.

[27] F. C. Hotz. Internat. Oph. Congress, 1900.

[28] G. E. de Schweinitz. Internat. Oph. Congress, 1900.

[29] Waldispühl. *Correspondenzblätt. für Schweizer Aerzte.*, Vol. 16, 1896, p. 3.

[30] P. Bunge. Exenteration des Auges. *Mittheil. aus der Universitätsaugenklinik zu Halle*, 1887.

[31] H. Knapp. A Case of Evisceration of the Eyeball, Followed by Orbital Cellulitis. *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 309.

[32] H. D. Bruns. Ophthalmic Surgery. *New Orleans Med. and Surg. Jour.*, Dec., 1909.

children, or in excitable and timorous persons. In case local anesthesia is employed, any suitable drug may be used, such as cocaine, stovaine, holocaine, novocaine, the Schleich method, etc.

Cocaine was first used for enucleation by Cocks[33] in 1884 and was afterwards recommended by A. D. Williams[34] in 1886; by Tossiwill[35], Bankart[36], Roper[37] and Lightfoot[38] in 188; by J. A. Campbell[39] in 1889; by Jackson[40], Armaignac[41] and Dunn[42] in 1892, by Chavez[43] in 1896, Terrien[44] in 1906; Ellis[45], Langworthy[46] and Siegrist[47] in 1907 and others.

Subconjunctival Anesthesia in Enucleation of the Eyeball.

Terrien begins his operations by producing conjunctival anesthesia and then using a sub-conjunctival injection of 1 cgm. of morphia. He then uses cocaine locally and hypodermically and proceeds to operate. When he is about to cut the optic nerve, he injects into the tissues surrounding the nerve 1 cc. of the following formula:

Hydrochlorate of cocaine	
Hydrochlorate of morphia, of each,.	.01
Stovaine,	
Sodium chloride, of each,	.02
Distilled water	5.00

He highly recommends this method, and says that hyperemic cases are the most painful and that in such cases holocaine acts the best.

Siegrist commences with a mixture of cocaine and adrenalin,

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[33]D. C. Cocks. Cocaine as a Local Anesthetic in Enucleation of the Eyeball. *Phila. Med. News*, Dec. 13, 1884, Vol. 45, p. 654.

[34]A. D. Williams. Enucleation of the Eyeball under Cocaine Alone. *St. Louis Med. and Surg. Jour.*, July, 1886, Vol. 41, p. 17.

[35]L. Tossiwill. Enucleation of the Eyeball with Intra-orbital Injections of Cocaine. *Lancet*, 1888, Vol. 1, p. 172.

[36]J. Bankart. *Lancet*, 1888, Vol. 1, p. 172.

[37]A. Roper. *Lancet*, 1888, Vol. 1, p. 172.

[38]C. L. Lightfoot. Enucleation of the Eyeball with Intra-orbital Injections of Cocaine. *Lancet*, 1888, Vol. 1, p. 824.

[39]J. A. Campbell. Atrophied Stump. Ossification of a Degenerated Choroid. *Jour. Oph., Otol. and Laryn.*, 1889, p. 60.

[40]E. Jackson. Anesthesia for Enucleation. *Annals Ophthal. and Otol.*, Jan., 1892, p. 3.

[41]H. Armaignac. *Journ. de Méd. de Bordeaux*, 1892, Vol. 12, p. 101.

[42]J. Dunn. Concerning the Use of Cocaine in Enucleation. *Virginia Med. Jour.*, 1892, Vol. 19, p. 959.

[43]L. Chavez. Algunas consideraciones sobre el tratamiento de la Oftalmia emigradora por la enucleacion. *Gaceta Med. de Mexico*, July 1, 1896, Vol. 33, p. 289.

[44]F. Terrien. De l'énucleation avec anesthesie locale. *Archiv. d'Ophtal.*, Feb., 1906, Vol. 26, p. 84.

[45]E. K. Ellis. Enucleation of the Eye with Cocaine. *Arch. of Ophthal.*, Vol. 36, No. 1, 1907.

[46]H. G. Langworthy. Enucleation of the Eye with Cocaine. *Arch. of Ophthal.*, Vol. 36, No. 1, 1907.

[47]A. Siegrist. Exenteration and Enucleation of the Eyeball Under Cocaine Anesthesia. Trans. from *Wiener Med. Presse*, June 2, 1907.

and then injects underneath the conjunctiva and over the four recti muscles 0.75 gr. of a 2 per cent solution of novocaine, to which some adrenalin has been added. By waiting two or three minutes after these injections he claims that a painless operation may be performed. He says that novocaine is less dangerous than cocaine and that he injected in one case 3.0 gm. of novocaine without producing any untoward symptoms.

Weiss[48], strongly urges the Schleich infiltration anesthesia for eyeball enucleations. He says that cutting of the optic nerve did not even give rise to the usual sensations of light generally observed in removing an eyeball without general anesthesia. The infiltration is made by injecting half a hypodermic syringeful of the Schleich solution beneath the conjunctiva, over the four recti muscles, and also by making deep injections near the optic nerve. For the last injection he uses Schleich's long curved needle. Edema, of course, follows which soon subsides after the operation.

Robin[49], in 1907, warmly recommended a mixture of cocaine and adrenalin, and injects it deeply along each rectus muscle, using "10 drops of a mixture containing 10 drops of a 4 per cent solution of cocaine, 10 drops of adrenalin chlorid (1/1000), and 20 drops of normal salt solution, of which 10 drops are injected about the optic nerve before severing. Total amount of cocaine injected is from 2-5 to ½ grain."

Where local anesthesia is considered advisable, the method usually prescribed is the following: A 4 per cent solution of cocaine should first be freely dropped upon the eyeball. After local anesthesia is produced, a 1 per cent solution of cocaine is subconjunctivally injected over the insertion of each rectus muscle, after which the circumcorneal incision and the undermining of the conjunctiva can be painlessly accomplished. The muscle tendons should then be anesthetized by injecting a few drops of a 1 per cent solution into the capsule of Tenon, just above each tendon, directing the stream along the plane of the muscle and close to the sclera, after which the tendons can be severed from their scleral attachments. A few drops of cocaine should now be injected into the tissues directly around the optic nerve and in a few minutes the nerve can be cut without much pain.

EYEBALL REMOVALS AND THE SUBSTITUTES FOR SUCH OPERATIONS.

Should it be determined to remove an eyeball, several different methods may be employed, viz., enucleation; evisceration; abscission;

[48]L. Weiss. Ausführung der Enucleation unter Schleichscher Infiltrationsanæsthesie. *Die Ophthal. Klinik.*, June 20, 1898, p. 214.

[49]E. A. Robin. A New Method of Enucleating Eyeballs Under Local Anethesia. *New Orleans Med. and Surg. Jour.*, Dec., 1907.

the insertion of an artificial vitreous within the sclera; the insertion of an artificial ball within the capsule of Tenon; the insertion of an artificial ball within the muscles and conjunctiva; and optico-ciliary neurotomy or neurectomy.

ENUCLEATION.

So far as can be ascertained the first scientific attempt at the extirpation, or enucleation, of an eyeball was made by Lange in 1555, who, however, failed to leave a record as to his method of procedure, although he reported his experience. About the *first recorded* method of enucleation, or "extirpation" as it was called, was described in 1583 by George Bartisch[50], of Königsbrück, in Saxony. Until about 1850 eyes were extirpated practically only in such cases as cancers, tumors, fungus hematodes, etc., and the method was rarely employed under any circumstances. Bartisch passed a strong needle and thread through the eyeball and then while making traction on the thread and eyeball, passed behind the eye a sharp knife, or spoon, and scooped and cut away the globe from all its attachments. Before permanently adopting the spoon knife, however, he first experimented with a small razor-shaped knife with which he severed the eye from its orbital attachments. The operation was so dreadful that Guthrie, in his work on the eye published in 1823, mentions the fact that Bartolini endeavored to mitigate its severity by pulling out a cancerous eye by hooks, a *mild* procedure, followed in three days by the death of the patient in convulsions.

Some of Bartisch's followers, including Fabrici de Hilden[51], who wrote on the subject in 1646, used a double-edged knife, instead of a spoon, after the conjunctiva had been separated from the blub by what is known as a circumcorneal incision. This method was used without many variations for years until Louis proposed, according to Rowley[52] in 1790, as a substitute for the knife, the use of flat, blunt, curved scissors and hooked forceps.

Mackenzie, in his work published in 1830, tells of a woman who had to undergo an eyeball extirpation on account of a large orbital tumor. She was bled until she was unconscious and the eyeball cut away before she recovered. This was certainly a novel manner of performing painless surgery.

Bickerton[53] says, "The severity of the operation is best shown by

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[50]Geo. Bartisch. *Ophthalmodouleia oder Augendienst*, 1583.

[51]Fabrici de Hilden. *Observation. Chirurg.*, 1646.

[52]Rowley. *Diseases of the Eye*, 1790.

[53]T. H. Bickerton. The Operative Treatment, Past and Present, of Injured or Painful Blind Eyes. *Medical Times and Gazette*, May 1, 8 and 15, 1897.

the rareness with which it was performed." He quotes Bowman, who says that at the Royal Ophthalmic Hospital from 1839 to 1848, al-

Fig. 211.
The Extirpation Method of Bartisch.

though 1,419 operations were performed, only four extirpations were made. During this period 2,302 cases of injury were seen, 24 cases of

"fungus of the globe" and 16 cases of tumors of the orbit. Bickerton further says that:

Fig. 212.
The Spoons and Knife of Bartisch for Enucleation of the Eyeball.

"Up to the year 1850, then, the only operations in vogue for the relief of injured and painful blind eyes were: (a) Simple incision of globe; (b)

'Sinking of the globe,' *i. e.*, a flap of the cornea was cut away by curved scissors, a dose of laudanum administered, and a linseed meal poultice applied to the eyelids, in order to evacuate the contents of the globe. (White-Cooper, *Wounds and Injuries of the Eye*, 1859, page 57).

"(c) 'Abscission,' *i. e.*, the removal by knife, scissors, or guillotine of a staphylomatous cornea, with suturing of the corneal margins.

"(d) Slicing off painful fungous growths, with application of nitrate of silver to the stump, a proceeding adopted in the cases of soldiers, where gunshot wounds had led to the sprouting of fungous growths from the interior of the globe, and attended with pain described as 'driving the sufferer to despération.' (White-Cooper, *loco cit.*)

"What the proportion of sympathetic inflammation, directly consequent upon the above methods of operation—apart from the original injuries—was, it is impossible to adequately estimate!"

On account of the brutal nature of the extirpation operation it was, as has been seen, but little used for years, when Ferrall[54] in 1841, Bonnet[55] in 1841 and Stoeber[56] in 1842, proposed and executed the operation for enucleation, which has always gone under the name of Bonnet's operation, although it should properly be called Ferrall's operation. Even now it is used by probably a majority of surgeons, who still take advantage of much of the surgical technic proposed by Geo.

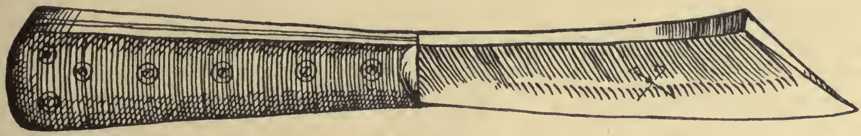

Fig. 213.
Another Knife used by Bartisch in Extirpation of the Globe.

Critchett in (*Lancet,* Vol. II, page 386, 1851) and by White-Cooper[57] in 1856.

When the eyeball seemed unusually large, either from natural or unnatural causes, the earlier operators were accustomed to slit the external canthus until the globe could be easily delivered, an expedient which is now but rarely used.

Ferrall stumbled across his operation rather accidentally, for, having a case of enormous orbital tumor in which the globe was entirely pushed out of the socket, he merely cut the ocular muscles, optic nerve, etc., and delivered the eyeball, and being much pleased with the results, reported his experience in the *Dublin Journal of Medical Science,* Vol. XIX, page 355, 1841. This article was entitled "On the Anatomy of Certain Structures in the Orbit Not Previously Described," and contained a recommendation of the operation in these words:

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[54]J. M. Ferrall. On the Anatomy and Pathology of Certain Structures in the Orbit Not Previously Described. *Dublin Jour. Med. Science*, Vol. 19, 1841, p. 335.

[55]A. Bonnet. *Ann. D'Oculist.*, Vol. 5, 1841, p. 27; and Vol. 7, 1842, p. 39.

[56]Stober. *Norris and Oliver's System of Diseases of the Eye.* Vol. 3, p. 883.

[57]White-Cooper. *Wounds and Injuries of the Eye*, 1859.

"The comparative safety of an operation limited by this fibrous tunic (referring to the capsule of Tenon) is obvious but an additional recommendation will be the facility of its performance. The conjunctiva being freely divided, the six tendons may be snipped across with scissors, one after another, where they emerge from the tunic. The eyeball will then be easily detached by a probe or director passed freely around it; when one step alone would remain, the division of the optic nerve."

The method was not much used, however, for some time, as the old operation of extirpation which was at about this time made less horrible by the discovery of chloroform had secured a firm hold on the profession, although in Skey's *Surgery* of 1850, (p. 623), it was said that "the use of chloroform in almost all operations on the eye is inadmissible from its well-known effects on the globe."

In narrating the early history of this operation, the work of Augustin Pritchard, of Bristol, should not be forgotten, for he, in 1850, was the first surgeon in England to extirpate an eyeball for a non-malignant condition. He enlarged the outer commissure and scooped out the contents of the socket with a knife and scissors. He became firmly impressed with the idea of sympathetic ocular disease and advised, in the *Provincial Medical and Surgical Journal* for 1851, page 66, and for 1854, page 909, the removal of the irritating eye.

Extirpation or enucleation was, until about the year 1855, used almost exclusively in cases of malignant growths, a deep incision of the globe being used in almost all other cases where surgeons to-day advise enucleation.

In 1885 Geo. Critchett read a paper before the Hunterian Society, which was reported in the *Lancet* for 1855, in which he advocated enucleation in staphyloma, intraocular foreign bodies, symblepharon, inflamed and painful blind eyes and inflamed eyes where sympathetic ophthalmia seems probable. This address widened the scope of this operation and placed it upon the broad foundation where it at present stands.

Choice of Method in Eyeball Excisions.

In removing all or any portion of an eyeball the method of operating is one to be carefully considered and decided by the surgeon. Every patient has a right to be deformed as little as possible by such a procedure, and to have provided for him the best and most movable stump, consistent with safety and the pathological condition present in his individual case. The importance of this statement, of course, varies with the age, sex, business and social position of the patient. For instance, personal appearance is of less importance in the aged and the mature laboring man than in the young people or among the so-called higher classes. It is of more importance in women than in men. As every one rebels against deformity each case should acordingly be given the benefits of the best advice. And, yet, probably a majority of the eyes

that are removed have been enucleated by the old-fashioned Ferrall or Bonnet method in which no effort is made to unite the muscles, conjunctiva, etc., in order to produce a prominent and movable stump upon which an artificial shell may rest and move. This method commends itself to many surgeons because it is easy and rapid, but it leaves the patient with a great, empty cup-shaped socket, which affords no support to the lids or to an artificial eye. The lids sink into the concavity when the shell is not in position, and even when it is, there is much depression, and, owing to the fact that no prominent and movable stump is present, the artificial eye stares into space, with deathlike immobility. This appearance is alike mortifying to the patient and discreditable to the surgeon, and in a vast majority of cases is entirely unnecessary, as better methods of operating may generally be used, producing such beautiful results as almost, if not quite, to abolish all disagreeable personal appearance. Of course, the old Ferrall, or Bonnet, operation is still necessary where complete exenteration of the socket for tumors, etc., is indicated, where expeditious operating is imperative, and, probably, where extensive orbital infection has occurred and free drainage is desirable, but in the vast majority of cases, this mutilating and deforming operation is entirely unnecessary and should be relegated to obscurity, that it may make way for better, more modern and more humane surgical procedures.

Preparation of the Patient and Surgeon for Enucleation.

In the operative descriptions given in this section it is assumed that all patients are properly prepared for operation by a thorough cleansing of the face, eye-brows and eye-lashes by plentifully scrubbing the parts with soap and water; the eyeball should also be abundantly douched with sterile water and some antiseptic solution. This should be done before the patient is brought to the operating room, after which a sterile pad and bandage should be applied. The same cleansing process should be repeated after the anesthetic has been administered and just before the operation is begun. A gauze mask in which a large hole has been cut to accommodate the affected eye should be placed over the face. The operator should wear thin, well-fitting rubber gloves. A strong speculum should be inserted between the lids, widely expanded and locked, although some surgeons prefer the use of a pair of Desmarres' retractors held by an assistant, feeling that the lids can be better and more effectually controlled by these instruments than by a speculum. These preliminaries should be accomplished in all eyeball removals, and it will not be necessary to repeat the directions each time the different procedures are described. It should also be assumed, to prevent recapitulation, that after all operations the operative area is cleansed thoroughly, that some antiseptic solution or ointment is

applied, that a pad and bandage are adjusted, that the parts are inspected, cleansed and treated each day and that all sutures, except those of catgut, are carefully removed within a proper period of time. I will also say that for general purposes, such as conjunctival and tendon cutting, I do not use the small, curved, tenotomy scissors employed by most surgeons, but prefer long, curved scissors of medium weight and rounded points, as they are more convenient to handle and do not stick into the tissues. I use long, heavy, curved scissors for cutting the optic nerve, and when catgut sutures are employed, prefer the Ramsey County chromatized catgut prepared in St. Paul, Minn., as it is reliable, strong and delicate.

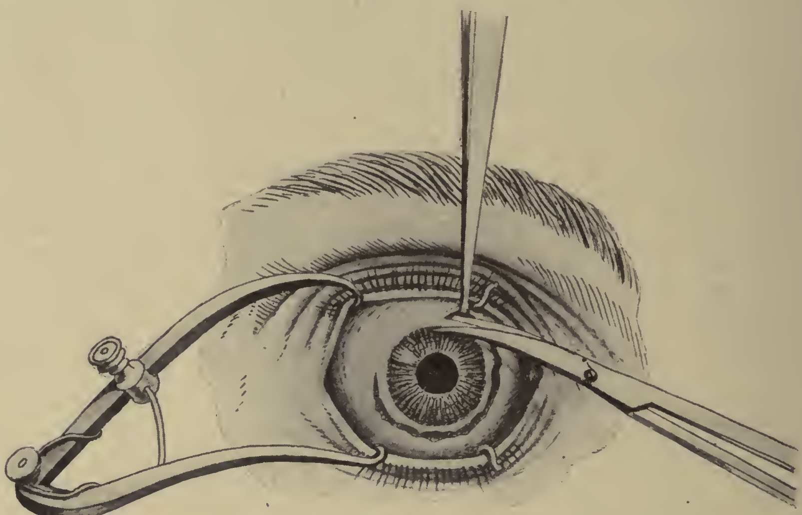

Fig. 214.
The Ferrall or Bonnet Enucleation. The Speculum has been inserted and the Circumcorneal Incision is being made.

THE FERRALL OR BONNET OPERATION.

After the speculum has been inserted, expanded and locked, the conjunctiva should be grasped with the forceps near the sclero-corneal junction, and an opening made with the scissors. This incision should be continued all the way around the cornea, completing what is known as the "circumcorneal incision," thus freely exposing the sclera and affording easy access to the recti muscles. The conjunctiva is now seized by the forceps in various places and lifted up to facilitate its thorough separation from the globe by scissors. This may be difficult of accomplishment if the tissues have become matted together by adhesive inflammation, or torn by injuries, but can be accomplished by careful and painstaking effort. The point of the scissors should be directed to-

wards the eyeball. This position of the cutting parts minimizes the danger of hemorrhage, as the cellular and orbital tissues are very vascular, bleed easily and are readily infected. Care should be taken not to cut the sclera, as this accident is not uncommon, especially in partially collapsed globes, and greatly complicates the succeeding steps of the operation.

The four recti muscles should now be separated from the eyeball and it is better to commence with the superior rectus, as the tendency is for the eye to roll upwards during anesthesia. When this muscle is cut such tendency is greatly minimized and the other tenotomies are more readily accomplished. In doing a *tenotomy* the overlying conjunctiva

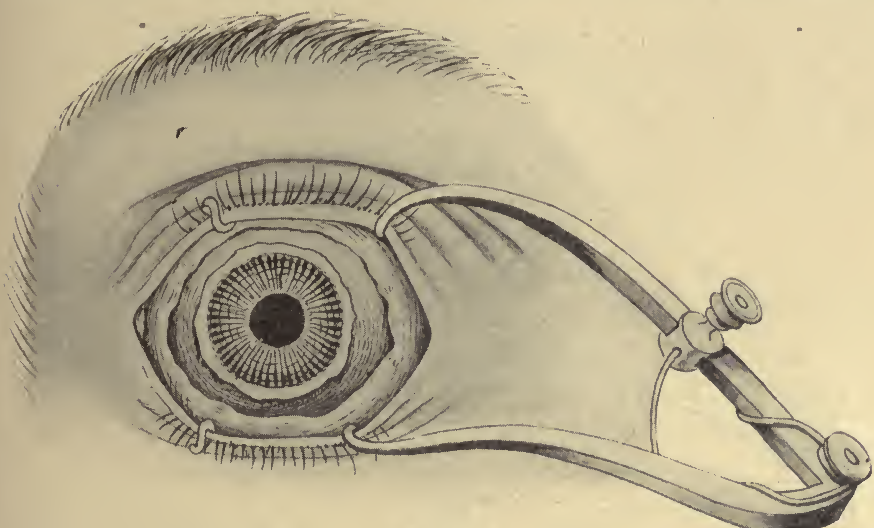

Fig. 215.
The Ferrall Enucleation Operation. The Circumcorneal Incision has been completed.

should be raised with the forceps and a strabismus hook forced underneath the tendon; the latter is then pulled forward and severed from its sclerotic attachment as close to its insertion as possible, taking great pains not to injure Tenon's capsule, as this membrane should always be conserved, if possible, to protect the soft orbital tissues and to improve the appearance and usefulness of the stump.

After all the tendons have been tenotomized, the speculum should be forced into the socket, which will cause the eyeball (no longer held in position by muscles, conjunctiva, etc.), to come forward and be delivered from its orbital bed; after which the speculum may be removed or not, according to the desire of the operator. Practically the globe is now held in place only by the optic nerve.

The Terson or DeWeltz enucleation spoon should at this stage of the operation be passed into the socket, between the eyeball and the posterior walls of the socket, and the optic nerve induced to slip into the slot of the spoon. Inasmuch as the optic nerve converges from the eyeball toward the nasal side of the socket, on its way to the optic foramen to join the optic nerve of the other eye, the nerve can be more easily found if the spoon is introduced beneath the eyeball from the nasal side, and it is usually best to insert it from this side. It can, however, be passed in from the temporal side, and it may sometimes be best to do this in case of a very large eyeball, where the space

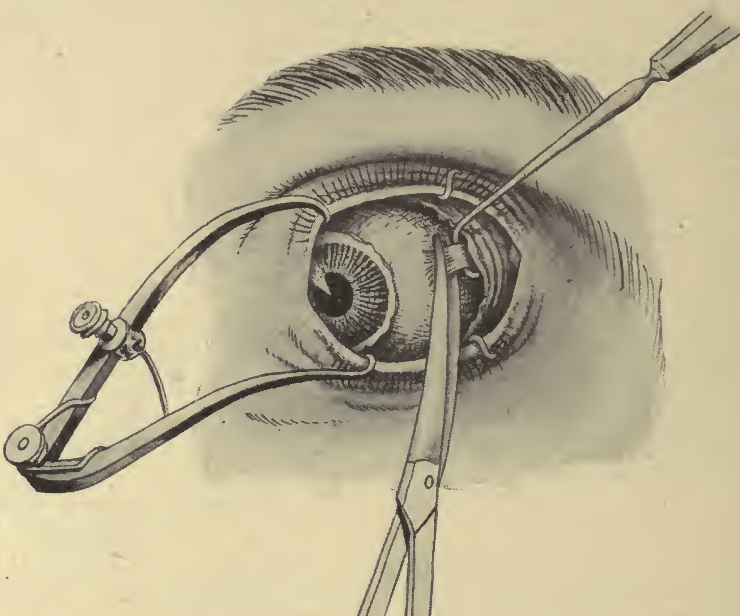

Fig. 216.
The Ferrall Enucleation. The Cutting of the Tendons.

between the globe and inner wall of the socket is much contracted. Some operators do not use the spoon, but lift the globe with fingers or forceps and pass the scissors underneath and sever the nerve. This may be facilitated by rotating the eyeball as far as possible to one side in order to bring the nerve as near to the surface as possible, when it can be more easily reached and cut. Some operators sever the nerve without dislocating the globe forward.

Geo. Suker in *The Ophthalmic Record* for January, 1902 recommended an enucleation forceps, shaped something like obstetric forceps, which can be introduced into the socket, back of the eyeball, one blade

at a time, and then locked. When the eyeball is detached, it can be withdrawn with the forceps.

Henry Joseph[58] has proposed what he calls a "Hook neurotome," something like a tonsil guillotine, which he claims can be placed around the nerve with great exactness and by means of which the nerve can be cut nearly as far back as the optic foramen.

If the spoon is used, it can be utilized to lift the eye from its orbital bed as far as possible and the strong, blunt, curved scissors should then be passed under the spoon and a search made for the optic nerve by means of the closed scissors blades. It will be felt as a strong, tense cord, especially if the spoon lifts the eyeball as high as possible, thus placing the nerve on a stiff tension. When found, the blades of the scissors should be opened and made to engage the nerve which is then completely severed as far back in the socket as possible.

This is especially important when there is fear of sympathetic ophthalmia; for if this disease travels along the optic nerve tissue by any form of cell-migration, the farther back the nerve is cut, the greater is the possibility of getting beyond the area of pathological invasion.

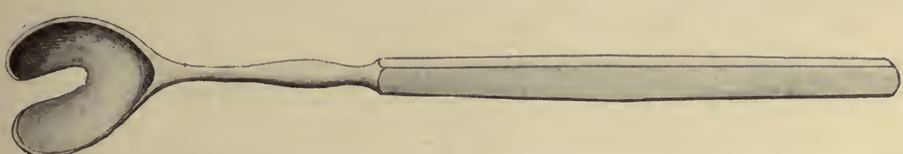

Fig. 217.
The De Weltz Enucleation Spoon.

While any strong, blunt, curved scissors will answer the purpose of cutting the optic nerve, those of Terson, suggested in 1905, are especially to be commended. The inner blade of these scissors is quite thick, so that when the nerve is cut the blade forces the eyeball forward, which insures the division of the nerve farther back than can be done by other scissors. The hemostatic scissors of Warlomont may, also, be used for the same purpose.

The blades of the scissors should be opened just wide enough to engage the nerve; if too much expanded more or less orbital tissue, blood vessels, etc., will be cut, unwise mutilation will result and the bleeding will be needlessly profuse.

When it is desirable to remove a large section of the optic nerve, Knapp has suggested that before severing the nerve a pair of curved catch-forceps be introduced behind the eye and the nerve securely grasped. The nerve should then be cut between the forceps and the eye,

[58]Henry Joseph. Crochet-neurotome pour sectionner le nerf optique. *Arch. d'Ophtal.*, Nov., 1904, p. 715.

the forceps left in position and the eye delivered. The nerve can then be drawn out and cut as far back as desired.

After severing the nerve the eye should be lifted by fingers or forceps, and the oblique muscles and all connecting tissues cut away close to the globe, until the separation of the eye from the socket is complete. Care should be taken to avoid cutting into the orbital tissues as troublesome hemorrhage may follow. Do not cut through the sclera during any stage of the operation, and especially when the optic nerve is severed, an accident liable to occur (as has been already mentioned) during the removal of wrinkled or collapsed globes. In the event of such an accident, the opening should be sutured at once, and if a piece of the sclera is found adherent to the optic nerve after the eyeball is removed, the nerve should be picked up with forceps and divided as far back in the socket as possible.

In case of a very large eyeball, as for instance in *buphthalmos,* the optic nerve may frequently be better reached from the temporal side.

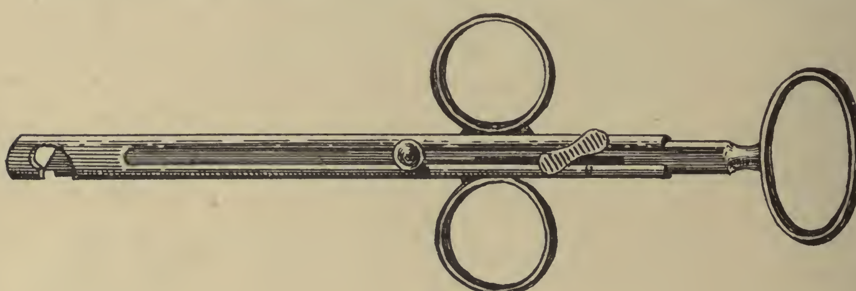

Fig. 218.
The Joseph Hook-Neurotome.

Before the globe can be delivered, in such cases, it may be necessary to enlarge the conjunctival opening made by the circumcorneal incision, by slits into its edges, between the locations of the muscles, as suggested by Meyer, in order to produce a circular space sufficiently large to permit of the egress of the abnormally large eyeball. It may even be necessary to enlarge the palpebral aperture by slitting the external canthus, although this is very rarely necessary and should only be done when imperatively demanded. When done, the incision should be sutured as soon as the eyeball is delivered.

Enucleation of Collapsed Globes.

It sometimes becomes necessary to remove an eyeball that has been ruptured or lacerated and is therefore somewhat collapsed. These globes are difficult of removal, for, being more or less collapsed and soft, they are hard to operate upon and present many obstacles to effecting a classical operation. In such cases a strong, curved needle

armed with a strong, long, silk suture should be passed directly through both sides of the laceration and the opening securely closed. The suture should not be cut off but allowed to hang, as it serves an excellent purpose in affording a means by which the eyeball can be pulled from side to side, thus facilitating the subsequent steps of the operation. If the eyeball is *much collapsed* it is advisable, before the suture is tightened into the knot, to inject it with sufficient water to force it into globular form, thus greatly aiding the surgical technique. Instead of filling the eyeball with fluid, the interior may be tightly packed with

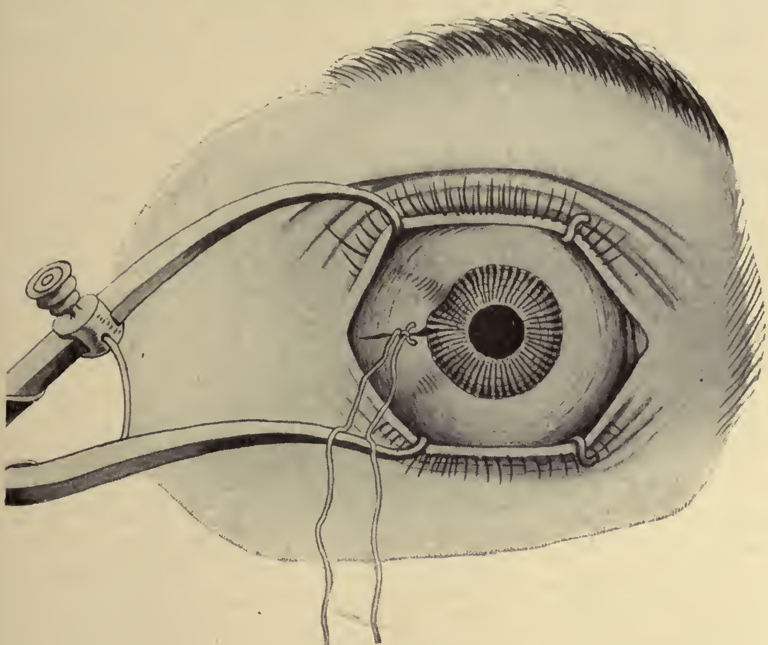

Fig. 219.
The Suturing of a Collapsing Globe during Enucleation.

cotton gauze or wool retained by the long suture or sutures already described.

E. L. Mather, of Akron, Ohio, in 1909 told me he had been in the habit of filling such globes with melted paraffin.

The laceration is sometimes so large that more than one suture is necessary to retain the intraocular contents, and this is also true when there is more than one laceration.

It is also advisable to use a suture where the coats of the eyeball are weakened by corneal ulceration, a recent operative incision as for cataract, etc. In such cases the globe is liable to rupture during enucleation, especially when the eyeball is forced from its socket, just before

the nerve is cut, thus embarrassing the operator at a most inopportune time.

The idea of suturing the eyeball before enucleation was taken advantage of by Coppez,[59] of Brussels, who in 1888 proposed to operate upon all eyeballs in this manner. He passed a strong suture through the anterior portion of the eyeball, then knotted it and held the suture in his left hand. Traction upon the suture pulls the eyeball forward and from side to side, so that the conjunctiva, muscles, optic nerve, etc., are all cut by scissors without the use of forceps or hook. It is difficult to conceive why this method is superior to others, and it certainly possesses some disadvantages; for instance, it would destroy many valuable pathological specimens.

After the eyeball has been enucleated it is advisable (especially where the globe has been injured by some projectile) to pass the finger into the socket and search for a foreign body, such as wood, metal, glass, etc., as sometimes such substances pass entirely through the eyeball and become deposited in the orbital tissues. Orbital tumors should also be searched for, and, if found, they should, of course, be removed. The presence of most foreign bodies in the eye or socket may be determined before operating, by the X-ray apparatus, and such skiagrams should always be insisted upon in cases involving any doubt.

Post-Operative Treatment of Simple Enucleation.

After the operation the socket should be well irrigated with an antiseptic solution, and a bandage applied. If the socket is infected it may be sprinkled with a little iodoform powder. Culbertson,[60] in 1904, advised packing the socket with iodoform gauze surrounded with perforated rubber dam, which can be removed at the first dressing without inflicting pain to the patient. The perforations also allow the secretions to escape.

The socket should be dressed every day and kept thoroughly clean, although Geo. R. Rohrer[61] tells me he no longer opens the lids, in non-infected eyes, at the dressings, but merely keeps the skin, lashes, etc., clean, and that he is much pleased with the results.

An artificial eye may be fitted in from two weeks to one month.

There is practically no danger from hemorrhage and it is not usually necessary to pack the cavity with gauze. Still Robert Sattler[62] and others have had much trouble in this respect not only with "bleed-

[59]H. Coppez. *La Clinique Ophtalm.*, 1888. Also abstracted in the *N. Y. Med. Record*. May 11, 1889.

[60]L. R. Culbertson. Rubber-dam Dressing after Enucleation. *Am. Jour. of Ophthal.*, Vol. 21, No. 4, April, 1904, p. 117.

[61]Geo. R. Rohrer. Personal Communication.

[62]Robert Sattler. Profuse Bleeding After Enucleation. *Jour. Am. Med. Assn.*, Vol. 27, 1896, p. 1097.

ers" but with non-bleeders, when almost fatal results have occurred. If troublesome hemorrhage should occur, adrenalized gauze may be packed into the cavity, or very hot water applied with cotton tampons forced into the socket, as recommended by Snell[63] in 1896. Carotid compression may be employed and even a carotid ligature may be necessary.

It should not be forgotten in this connection that cotton, sponge, etc., are easily grafted into the orbital tissue, and that if such substances are unfortunately left in the socket for even a day or two, they will very likely have to be actually cut out, a complication as embarrassing as unfortunate.

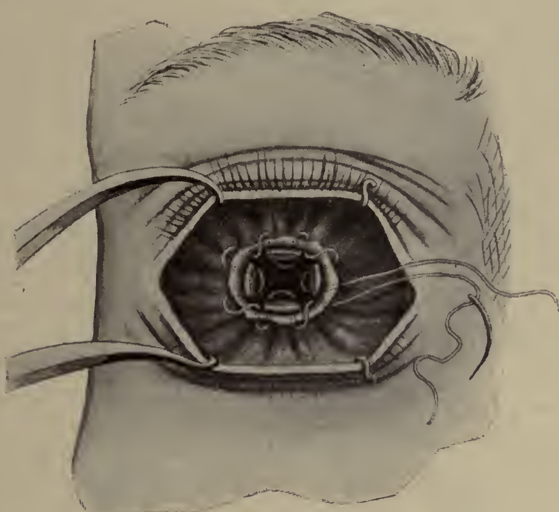

Fig. 220.
Enucleation of the Eyeball. Würdemann's Purse-String Suture, Including Conjunctiva, Capsule and Tendons.

Suture of the Wound Margins after Enucleation.

Some surgeons complete the operation by bringing the conjunctiva togethed either with individual sutures, or a purse-string suture of catgut or silk. Others, as recommended by Bowman, search for the recti muscles and include them with the conjunctiva in the sutures, although it is difficult to find the muscles after they have been severed and allowed to retract into the socket.

Würdemann[64] in 1893 made a *pouch suture* by weaving the needle and suture along the edge of the cut conjunctiva and Tenon's capsule.

[63]Simeon Snell. A Short Note on the Value of the Immediate Use of Hot Water After Enucleation. *Ophthal. Review*, Oct., 1896.
[64]H. V. Würdemann. Sympathetic Ophthalmitis. *Ophthal. Record*, Vol. 3, No. 5, 1893, p. 177.

As he passes the recti tendons he picks each one up and includes it in the suture. Other operators recover the four recti muscles and suture them together with catgut and then tie the conjunctiva over the muscles with an interrupted or a purse-string suture. In the presence of orbital pus the conjunctiva and muscles should not be stitched together, as the entire cavity should be left freely open for drainage and for the prevention of deeper infection.

Allport's Operation.

The enucleation operation which I usually employ, and which I described in *"Medicine"* in 1901, is the same as the Ferrall or Bonnet operation up to the step where the tendons are separated from the eye-

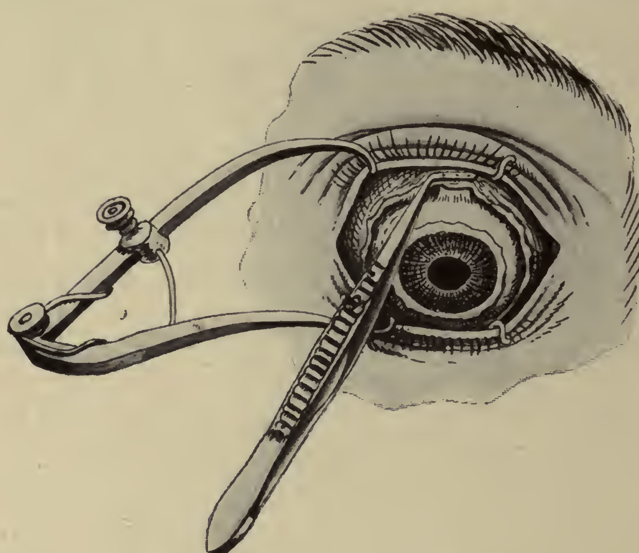

Fig. 221.
Enucleation of the Eyeball (Allport). The Advancement Forceps of Prince, Holding within its Grasp the Conjunctiva, Capsule of Tenon and the Tendon of the Superior Rectus Muscle.

ball; at this juncture, instead of cutting off the tendons and allowing them to retract into the socket, I proceed as follows: The superior rectus is caught on a strabismus hook and pulled away from the eyeball. Another hook is then passed beneath the muscle and while one hook pulls the muscle from the eyeball the other is passed backward and forward between the eyeball and muscle to free entirely the muscle from any fibers connecting the muscle and globe. The second strabismus hook is then withdrawn, leaving the first in place. One blade of a strong pair of Prince's advancement forceps is then placed between the tendon and sclera, taking the place of the remaining strabismus

hook, which is now withdrawn. The edge of the conjunctiva lying over the muscle is seized by a pair of forceps and pulled forward, together with the capsule of Tenon, and the outside blade of the Prince's forceps brought down upon them and locked. The bent ends of the forceps now contain the tendon, capsule of Tenon and overlying conjunctiva. The tendon is separated from the eyeball by scissors passed between the forceps and the sclera, being careful not to wound the latter structure.

A needle and catgut suture should now be passed by means of a needle-holder through the conjunctiva, capsule of Tenon and tendon from without inwards and then back again from within outwards. This

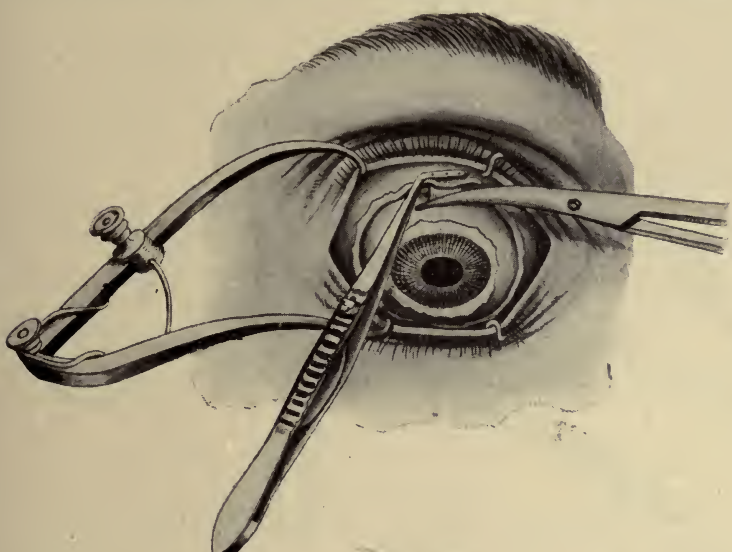

Fig. 222.

Enucleation of the Eyeball (Allport). The Advancement Forceps of Prince Holds with its Grasp the Conjunctiva, Capsule of Tenon and the Tendon of the Superior Rectus Muscle, while the Tendon is Being Severed from the Globe.

quilts the entire mass together by means of a firm, solid stitch that will not pull out; after which the two ends of the suture are carefully laid aside so as not to interfere with the next step in the operation. The external rectus is then picked up, liberated, engaged in the Prince's forceps together with the conjunctiva and capsule of Tenon, cut away from the sclera, quilt-stitched with the same needle and suture, etc. The same steps are taken (in their order) with the inferior and the internal rectus, after which the needle may be withdrawn from the suture. The purse-string suture and its two free ends should be laid carefully aside to facilitate the subsequent steps of the operation which are ex-

actly the same as in the Ferrall or Bonnet operation just described. The operation is completed by pulling the continuous suture containing the recti muscles, the capsule of Tenon and the conjunctiva together and tying the mass in a firm, hard knot. Great care should be exercised when the scissors are introduced to sever the optic nerve, that the suture is not cut in the process, an accident which is not at all impossible. If, however, this misfortune should occur the muscles should be painstakingly picked up and the continuous, purse-suture re-introduced as before.

The employment of this operation for over ten years has convinced me of its efficiency and usefulness. It forms a well-placed orbital wall which prevents much sinking of the lids, and produces a

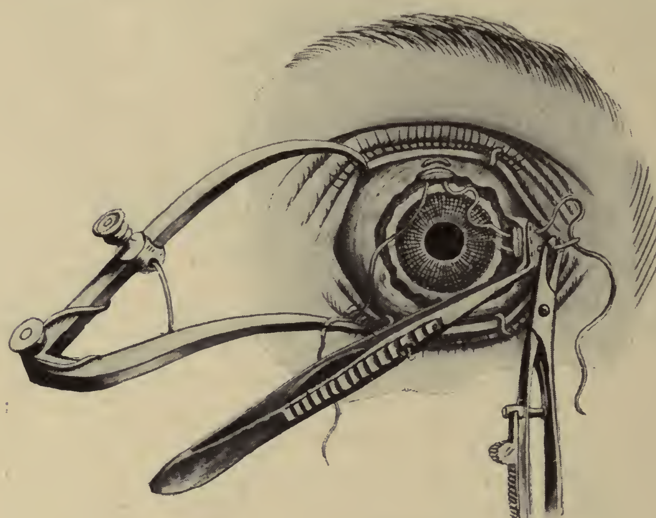

Fig. 223.

The Enucleation of the Eyeball (Allport). The "Quilting" of the Conjunctiva, Capsule of Tenon and the Tendons of the Recti Muscles.

The operator, of course, begins on any muscle he chooses and works around the eyeball in either direction. In the drawing, he begins with the superior rectus and proceeds to the internal rectus. Thence he passes to the inferior rectus and the external rectus.

freely-moving stump upon which an improved Snellen eye may rest and move in a manner that almost defies detection. I have had a wide experience of the Mules operation, but the cosmetic results of the procedure just described are so good that I now confine the Mules operation to selected cases where the personal appearance of the patient is a matter of the very highest importance.

In 1879 and 1885 de Wecker[65] suggested placing a purse-string suture through the conjunctiva, capsule and tendons, after the circum-corneal

[65]L. de Wecker. *Thérapeutique oculaire*, 1879, p. 512.

incision had been made, but before the tendons were severed. The globe was then enucleated and the suture firmly tied.

Snell[66] suggested, in 1902, that after the circum-corneal incision, one of the recti muscles be caught up on a strabismus hook and a suture be passed through it from side to side and tied. The suture is then passed through the overlying conjunctiva. This end of the suture is cut long and the other short. The tendon is then severed and the other muscles similarly treated. After the eyeball is removed the lateral and, then, the vertical muscles are tied together with the long ends of the sutures. An additional suture in the conjunctiva, at each extremity of the wound, is usually necessary.

Ernest Clarke,[67] in 1902, suggested picking up the external rectus with a hook and clamping it with Prince's forceps. He then severs the tendon. The internal rectus is treated similarly. The superior and inferior recti are merely cut and not clamped. The eyeball is then removed. A catgut suture is now passed through the external rectus and the clamp removed. The same suture is passed through the capsule of Tenon and conjunctiva, and tied. The internal rectus is treated similarly. The upper and lower lips of the wound are brought together with silk sutures.

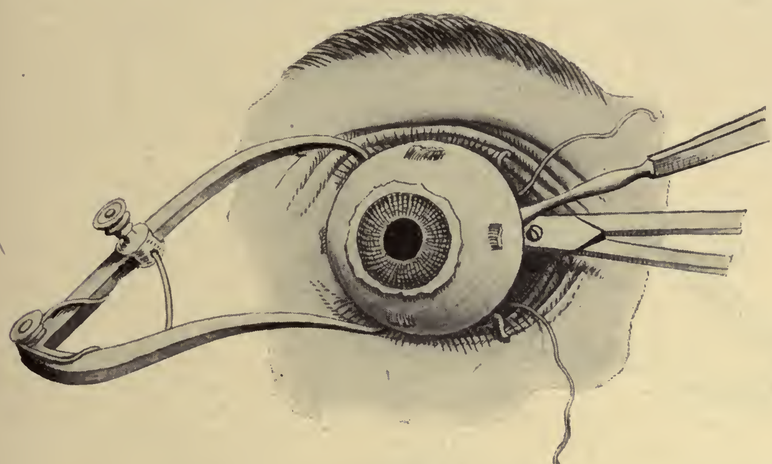

Fig. 224.

Enucleation of the Eyeball (Allport). The Muscles have been Severed and the Eyeball Forced from its Socket. The Two Ends of the Suture are Laid Aside and the Slot of the Enucleation Spoon has Engaged the Optic Nerve. The Strong Curved Scissors are Severing the Optic Nerve.

In 1895 Suker[58] suggested the following operation:

"Prepare the field of operation as is your custom; divide the conjunctiva as close to the cornea as possible, dissect it is far back as permissible; do the same with the capsule of Tenon. Cut the recti muscles as close to their insertion as possible. Insert into each rectus a black silk suture at the time it is cut. This is to act as a guide. Proceed now as is customary, *i. e.*, severing the nerve and oblique muscles. After removing the eye, take a thoroughly sterilized catgut suture and pass it through the severed end of

[66]Simeon Snell. On a Method of Suturing the Tendons to Form a Better Stump After Enucleation of the Eyeball. *British Med. Jour.*, Vol. 2, 1902, p. 1430.

[67]Ernest Clarke. A Method of Suturing the Lateral Recti. *Lancet*, May 23, 1908.

[68]Geo. F. Suker. The Formation of the Stump After an Enucleation. *Annals Ophthal. and Otol.*, Vol. 4, No. 4.

the rectus externus and internus, which have previously been brought together by the silk suture guides.

"Now bring the superior and inferior recti down and pass a catgut suture through them. Finally, suture the four together and remove the silk guides. Thoroughly irrigate your cavity with sterilized water. At the last bring the conjunctiva from above and below over the muscle stump and suture same with a continuous suture, but be sure you fasten it to the muscle stump. Leave only a small part unsutured at either canthal end of the conjunctiva as a provisional drainage opening.

"You will, if everything acts properly, have union by first intention and the result will be an excellent prominent stump upon which an artificial eye will fit exceedingly well. This stump permits of much freer movement of the shell than any other, and then, too, it does away, more or less, with the extreme sunken appearance of the socket after an enucleation. You are also apt to preserve a much better caruncle than is obtained by the other operations."

In 1895 Würdemann suggested an operation very similar to that of Suker.

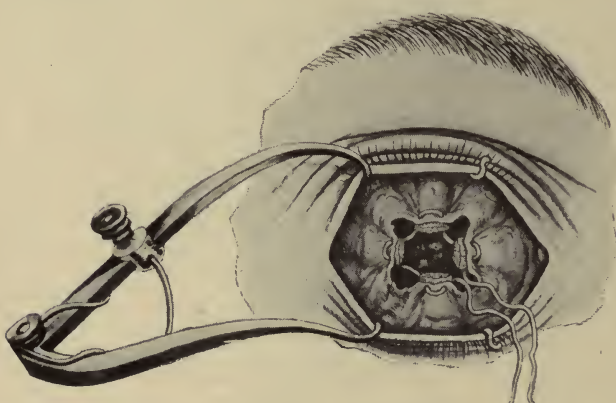

Fig. 225.

Enucleation of the Eyeball (Allport). The Sutures Now Contain the Conjunctiva, the Capsule of Tenon and the Four Recti Muscles, and are about to be tied.

In 1897 H. Schmidt[69] suggested that each rectus tendon be secured by a catgut suture. He makes an opening in the overlying conjunctiva into which the divided tendon is fastened. The conjunctiva is then brought together with a continuous suture.

In 1899 Priestley Smith[70] proposed the following operation:

"The speculum having been introduced the globe is rotated strongly upward either with forceps, or more conveniently in some cases, by pressing the convexity of a strabismus hook deeply into the sulcus at the external canthus. A narrow horizontal fold of the conjunctiva over the internal rectus is then pinched up so as to include the subjacent connective tissue and muscle, and a black silk suture is carried through these structures by means of a curved needle.

"The suture is then tied firmly, but not too tightly.

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[69]H. Schmidt. Enucleatio Bulbi mit beweglicher Prothese. *Klin. Mon. f. Augenheil.*, Nov., 1896, p. 383.

[70]Priestley Smith. On the Mobility and Position of the Artificial Eye. *Ophthal. Review*, May, 1899, p. 121.

"A second suture is applied in like manner to the external rectus. The upper and lower recti may be treated in the same way, but this is of less importance. The enucleation is then carried out, and the conjunctival aperture may or may not be closed by one or more vertical sutures."

In 1900 de Schweinitz[71] suggested the following procedure:

"After insertion of a speculum which widely separates the lids, the conjunctiva is divided as close as possible to the corneal margin; each rectus tendon is next exposed and caught upon a hook, as in the operation for strabismus, and is secured with a double-armed black silk suture, which is knotted upon it. The eyeball is now enucleated with the least possible disturbance of the relations between the conjunctiva and the underlying structures, and a small ball of sterilized gauze is inserted into the capsule of Tenon, in the manner in which a Mules' sphere would be placed in the operation of implantation. Each rectus tendon is now drawn forward to the edge of the cut conjunctiva and securely fastened with the ends of the same suture which had originally secured the tendon and which have been left long. That is to say, the tendon is brought forward precisely as it would be in the operation of advancement. The wad of sterilized gauze,

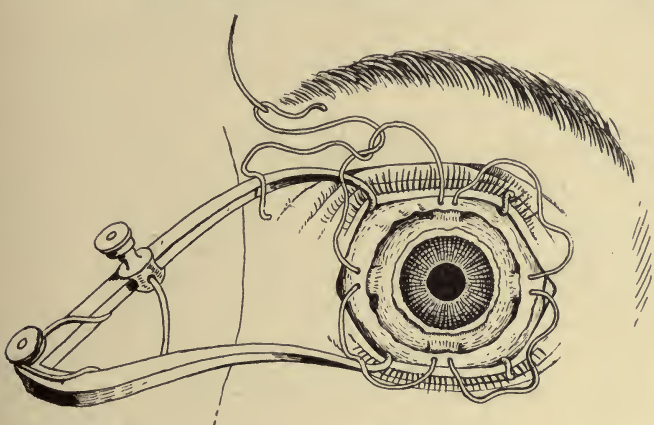

Fig. 226.

Enucleation of the Eyeball. de Wecker's Purse String Suture, Inserted before the Tendons are Cut.

which has served its purpose of checking entirely the hemorrhage and keeping for the time being the cavity bulged out as it was when occupied by the globe and therefore has facilitated the advancement of the tendons, is now removed, and the edges of the conjunctiva and capsule of Tenon are united with interrupted sutures."

In 1902 Todd[72] advised that—

"After severing and dissecting up the ocular conjunctiva in the customary manner the superior rectus is picked up on a hook, a curved needle is passed from without inwards through the conjunctiva and tendon, and out again through the tendon and conjunctiva, thus forming a loop which includes the tendon and conjunctiva; the tendon is then severed near its scleral attachment. The internal rectus is now picked up with a hook and the same thread carried in the same manner through the conjunctiva and tendon, after which the tendon is severed. The same thread is carried on

[71] G. E. deSchweinitz. Concerning the Substitutes for Enucleation. *Therapeutic Gazette*, April 15, 1900.

[72] F. C. Todd. Simple Method of Suturing the Tendons. *Ophthal. Record*, May, 1902.

around in the same way through the inferior rectus and external rectus, and their tendons cut. The optic nerve is severed and the globe removed. The two ends of the thread are then tied, and the tendon and conjunctiva are thus brought together with a purse-string suture."

In 1903 Hansell and Sweet proposed that after the circum-corneal incision is made, the conjunctiva, capsule and each tendon should be singly sutured. Then the tendons are severed, the globe removed and the tissues pulled together with the sutures.

The Vienna Method of Enucleation.

The method in vogue in Vienna and some other medical centers is as follows: The first part of the operation, including the circum-corneal incision, etc., is practically the same as already described; the only

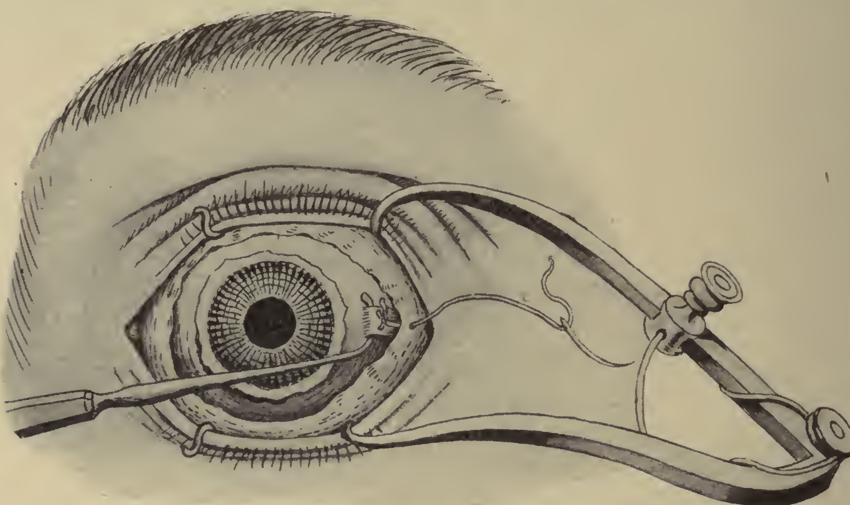

Fig. 227.

Enucleation of the Globe, The Circum-corneal Incision has been made, the External Rectus Tendon has been caught on the Strabimus Hook, the Suture has been passed through the Tendon, from side to side, and tied. One end of the Suture has been cut off and the other end has been passed through the overlying conjunctiva. (Simeon Snell.)

essential difference consists in the severing of the tendons, since no tendon hook is used. It is usual to begin the operation on the tendon of the internal rectus. The conjunctiva covering this muscle is elevated with one hand, while the other holds a strong pair of toothed forceps with which to grasp the tendon and draw it forward. To do this the closed forceps are carefuly introduced through the opening in and beneath the conjunctiva, along the line of the internal rectus muscle, keeping the end of the forceps in contact with the eyeball. When the tendon is felt the forceps are opened and the tendon firmly grasped and pulled forward. The tendon is then severed by scissors, *not* be-

tween the forceps and eyeball, as is done in a tenotomy, but between the forceps and the internal canthus, to leave a piece of tendon attached to the eyeball sufficiently long that it can be grasped by forceps and be used as a sort of handle to move the eyeball in such various directions as are necessary to complete the subsequent steps of the operation. A blade of the scissors is now pushed upwards toward the superior rectus muscle, keeping close to the sclera, the eyeball meanwhile being rotated downwards by the forceps acting on the internal rectus tendon. When the superior rectus muscle is found its tendon is cut close to the two blades of the scissors. The eyeball is now pulled towards the nose, while

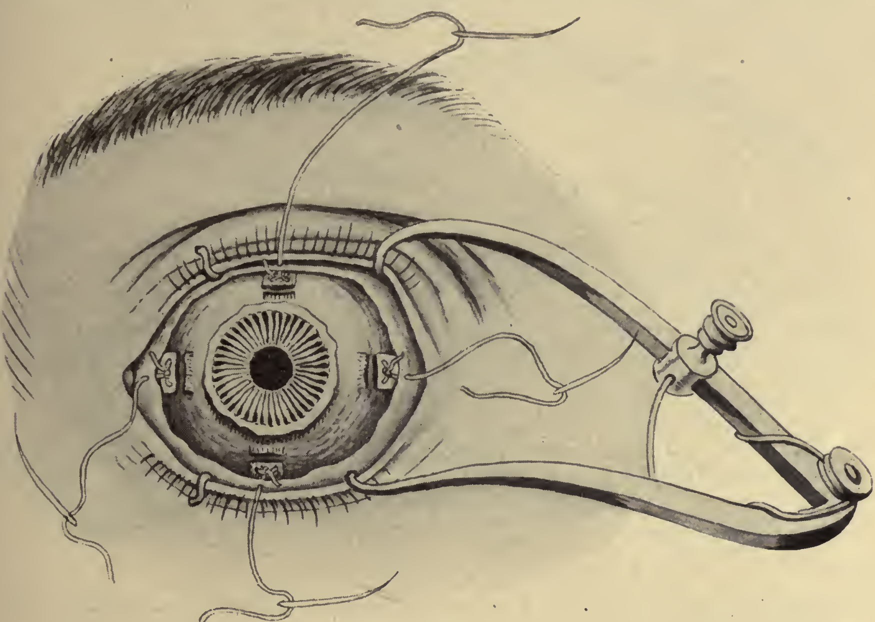

Fig. 228.

Enucleation of the Eyeball. All the muscles have been treated in the manner shown in the previous figure. (Simeon Snell.)

the external rectus is searched for and severed. The inferior rectus is not cut until the optic nerve is severed—the next step in the procedure. The eyeball is pulled toward the external canthus as far as possible by the forceps and internal rectus stump, a pair of strong, curved, blunt scissors introduced behind the eyeball close to the sclera until the nerve is found, the blades are opened and the nerve severed. The eyeball is now pulled away from the socket by the forceps and internal rectus tendon, and the internal rectus and oblique muscles cut away as close to the sclera as posible. The subsequent procedures are not different from those already described under the Ferrall or Bonnet operation.

Arlt's method of enucleation (1859), described by H. Knapp,[73] is as follows; he uses no strabismus hook:

"He incises the conjunctiva from 2 to 3 millimeters behind the limbus corneæ, and pushes it somewhat back. Standing on the right of his patient, he in the left eye, divides first the external, in the right the internal rectus, grasping it with toothed forceps, but leaves a small stump to get a firm hold of the globe with the forceps. After division of the inferior and superior recti, he pulls the eye with the forceps horizontally towards the inner (or outer) canthus, passes a pair of scissors over the posterior segment of the sclerotic, as far as the optic nerve, opens the branches, advances the scissors, so that the nerve lies between the branches, and cuts it close to the sclerotic. He now turns the protruding eyeball to the side of the uncut rectus, divides the insertions of the obliques, and the vessels and nerves, at the posterior half of the globe, and lastly detaches the insertion of the fourth rectus, together with the overlying conjunctiva, from the sclerotic."

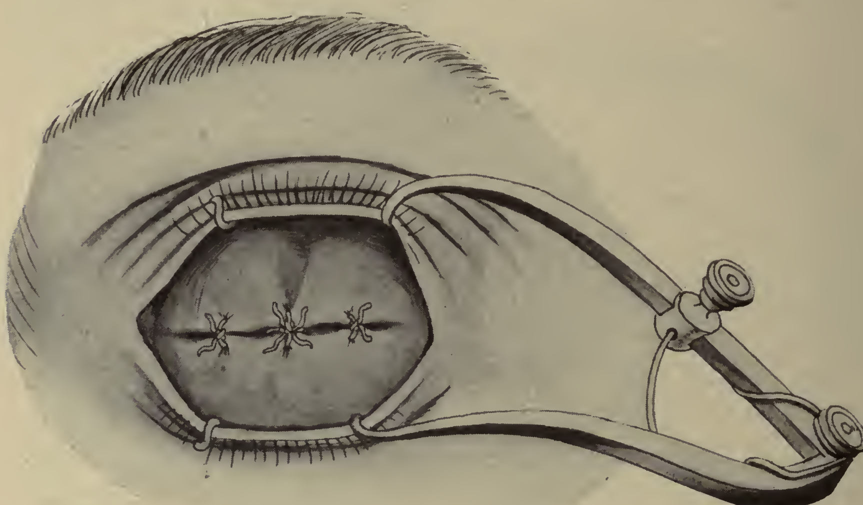

Fig. 229.

Enucleation. The Sutures have all been tied together in the center, and an Additional Suture has been applied at each end of the wound to prevent gaping. (Simeon Snell.)

H. Knapp's[74] own method of operating is practically the same as the Ferrall or Bonnet method, only he does not make the circum-corneal incision; he cuts the conjunctiva as he goes around the globe, at the same time as he cuts the tendons, feeling that thereby he saves considerable conjunctival tissue. At the end he closes the conjunctival wound by a purse-string suture.

Tillaux, in 1872, proposed a modification of Ferrall's or Bonnet's method.

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[73]H. Knapp. *System of Diseases of the Eye*, Norris and Oliver, Vol. 3, p. 885.

[74]H. Knapp. *System of Diseases of the Eye*, Norris and Oliver, Vol. 3, p. 885.

He severed the external rectus and then drew the eyeball toward the nose and cut off the optic nerve. He then grasped the stump of the nerve attached to the eye, with forceps, and rotated it forward through the conjunctival wound. He then cut the other recti and the oblique muscles, and the capsule of Tenon, and delivered the globe.

Cunier endorsed the method of Tillaux, but he reversed the procedure and commenced with the internal instead of the external rectus.

Agnew's method of enucleation, as described by Beard,[75] is essentially as follows:

After making the circum-corneal incision, and undermining the conjunctiva, the superior rectus is caught by a strabismus hook and cut. Before freeing the point, however, another hook is passed under the internal rectus tendon, thus keeping the globe fixed from time to time by the hooks instead of forceps, as muscle after muscle is severed. Enough of the external rectus is left attached to the globe to serve as a handle, to be held by the forceps, so that the eye may be pulled toward the nose, in order to bring the optic nerve and oblique muscles into prominence, to facilitate their severance by the scissors.

E. Meyer,[76] in 1898, emphasized the importance of preserving all possible ocular and orbital tissue. He refrains from cutting either capsular or subconjunctival tissue, and when the tendons are severed

Fig. 230.

Enucleation. Diagram Showing the Suture Passed Through the Tendon (Ernest Clarke.)

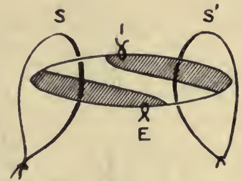

Fig. 231.

Enucleation of the Eyeball. Diagram Showing the Internal and External Recti Muscles Sutured to the Conjunctiva, and the Entire Mass Brought Together with other Sutures. (Ernest Clarke.)

he lifts them with a hook and carefully shaves them from their scleral attachment with a knife. He closes the conjunctival and capsular openings by vertically placed sutures in order to improve the lateral movements of the artificial eye.

Monosmith[77] has recently devised a knife which he uses, instead of scissors, for enucleating eyeballs. The knife resembles a Weber canaliculus knife bent to an angle of 45 degrees. The point is thin and blunt to facilitate its passage beneath the muscles and conjunctiva. The knife is passed underneath the muscles which are severed without the use of either hook or scissors.

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[75]Beard. *Ophthalmic Surgery*, 1909, p. 459.

[76]E. Meyer. Some Remarks Upon the Technique of Enucleation. *Révue Générale d'Ophtal.*, May 31, 1898, and *Bulletin et Mém. de la Soc. Franç. d'Ophtal.*, 1898, p. 185.

[77]O. B. Monosmith. Personal Communication.

De Wecker,[78] in 1902, strongly opposed enucleation except in imperative cases, and tattoos the globe to imitate a natural appearance. To assist in restoring the size of the globe and of advancing its position, he divides the recti muscles which retract and constrict the eyeball. This procedure has also been recommended by Darier and by Trousseau in *La Clinique Ophthalmologique*, Vol. XI.

It should not be forgotten, in this connection, that tattooing is sometimes followed by sympathetic ophthalmia, as was attested by Rava in 1872, Reuss in 1873, Panas[79] in 1878, as well as by Lucas-Championniere, Girand-Teulon and others.

Buttons of granulation tissue occasionally appear in the socket, after enucleation. They can be easily snipped off.

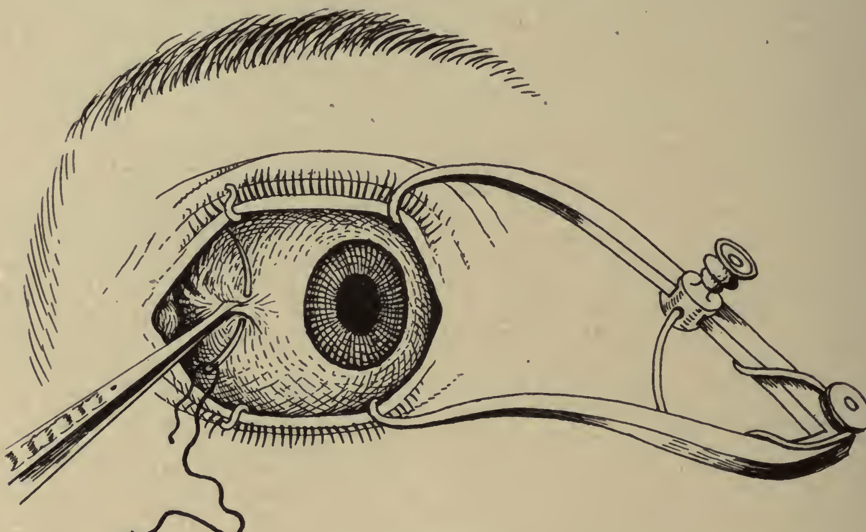

Fig. 232.

Enucleation of the Eyeball. (Priestley Smith.) The Conjunctiva and Internal Rectus Muscle are Clamped by Forceps, and Transfixed by a Needle and Suture.

Lamentable but, fortunately, rare instances have occurred where the wrong eye has been removed. This should not be forgotten, and great care should always be exercised that this dreadful calamity does not befall both the patient and surgeon.

Self-enucleation of an eyeball is one of those horrible incidents only of scientific interest from the fact that it demonstrates the constant care that should be given to insane people. Noyes,[80], in 1907, records

[78] L. de Wecker. Tattooing; a Substitute for Ocular Prothesis. Trans. from *La Clinique Ophtal.*, May 25, 1902.

[79] P. Panas. *Gazette des Hôpitaux*, No. 85.

[80] G. L. Noyes. Report of a Case of Self-Enucleation of the Eyeball. *Ophthal. Record*, March, 1897.

such a case and other instances have been noted by Mackinlay,[81] McHardy,[82] Dearden[83] and others.

Lundsgaard in the *Klin. Monatsbl. f. Augenheilk.*, page 131, 1909, reports the case of an insane woman, who, within two minutes tore out the eyes of another insane woman. There were no witnesses to the occurrence, but there can scarcely be a doubt as to the verity of the incident.

ABSCISSION AND EVISCERATION (EXENTERATION) OF THE EYE.

The history and evolution of evisceration are so intimately connected with abscission that it is difficult to refer to the one without including the other. I will, therefore, take them up as one subject.

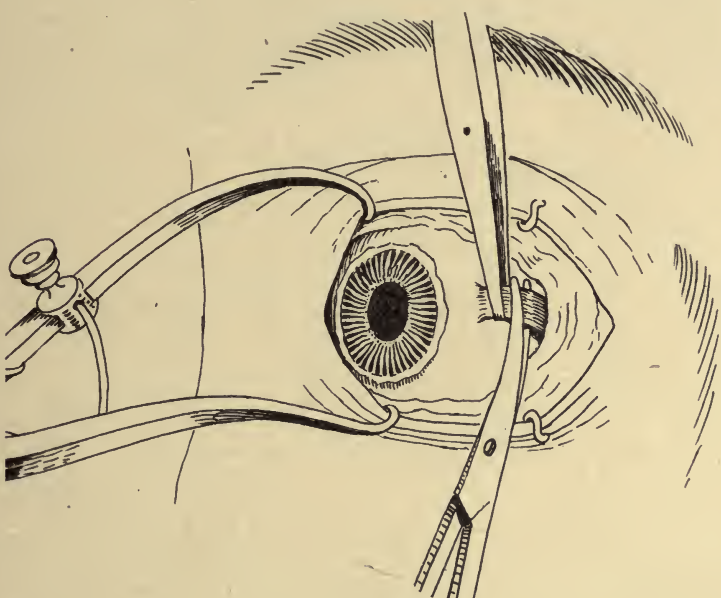

Fig. 233.

Enucieation. The Vienna Method. The Circum-corneal Incision has been Made and the Muscle has been Grasped by the Forceps close to the Eyeball. The Scissors are Cutting the Muscle between the Forceps and the Belly of the Muscle.

Evisceration of the eye was performed (rather unintentionally) by James Beer[84] in 1817 in a case of hemorrhagic glaucoma where severe choroidal hemorrhage occurred during an operation for iridectomy; by

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[81]J. G. Mackinlay. Complete Self-Enucleation of Eyeball. *Trans. Oph. Soc. of U. K.*, 1887, p. 298.

[82]M. McHardy. *Trans. Oph. Soc. of U. K.*, Vol. 6, 1886, p. 476.

[83]John Darden. (Mackinlay.) Complete Self-Enucleation of Eyeball. Trans. Oph. Soc. of U. K., 1887, p. 298.

[84]James Beer. Graefe-Saemisch, *Handbuch der ges. Augenheilk.*, Vol. 3, p. 376.

Butter[85] in 1834; by Barton[86] in 1837; by Noyes[87] (1872) in panophthalmitis; and by Fröhlich[88] in 1881. It was deliberately proposed by Graefe[89] and Mules[90] in 1884 to minimize the danger of meningitis, and is now sometimes employed as a substitute for enucleation. Early in the history of this operation Mulder[91], of Gröningen, seriously considered the advisability of this procedure as a routine substitute for enucleation, and performed many experiments on cadavers and animals to demonstrate its practicability.

Wardrop, in his *Morbid Anatomy of the Human Eye,* published in 1834, notes that veterinarians observed that horses with one suppurating eye frequently become blind in the other eye, unless the first

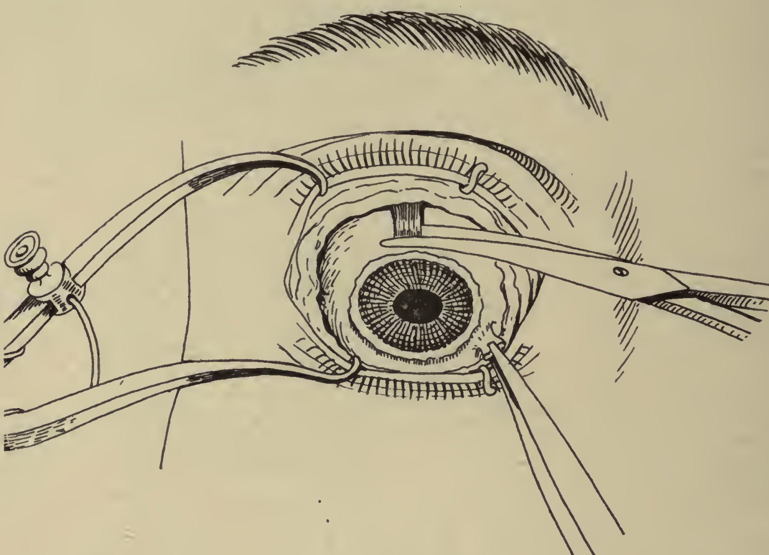

Fig. 234.

Enucleation. The Vienna Method. The Stump of the Internal Rectus Muscle is Held by the Forceps, while the Superior Rectus is being Cut with Scissors.

eye burst and sank into the orbit. They, therefore, conceived it to be good practice to burn out the first eye with lime, or to thrust a nail into it and destroy it. Wardrop improved upon this method by incising

[85]Butter. *Medical Gazette*, 1837.
[86]Barton. *Medical Gazette*, 1837.
[87]H. D. Noyes. Graefe-Saemisch, *Handbuch der ges. Augenheilk.*, Vol. 3, p. 376.
[88]C. Fröhlich. Celluloide Prothesen. *Klin. Monatsbl. f. Augenheilk.*, 1881, p. 349.
[89]Alfred Graefe. Enucleation oder Exenteratio-Bulbi. Address before the *Society of German Naturalists and Physicians in Magdeburg*, Sept. 1, 1884.
[90]P. H. Mules. *Trans. Oph. Soc. of U. K.*, 1898, p. 233.
[91]M. E. Mulder. *Graefe-Saemisch Handbuch*, p. 117.

the cornea and forcing out the lens and vitreous humor. He suggested this procedure in human beings threatened with sympathetic disease of the other eye.

Mackenzie[92], in his *Treatise on Diseases of the Eye*, 1834, mentions a case reported by Dr. Butter, of a gun-shot wound of the eye where the lens and vitreous were removed to save the eye, but where the globe was subsequently enucleated and a duck-shot found near the optic nerve. Mackenzie again, in 1837, mentions the suggestions of Mr. Barton in the treatment of the retention of percussian caps within the globe. He made a large corneal flap with a Beer's knife and then thrust the knife into the lens and vitreous to encourage their discharge, meanwhile hoping the cap would present itself. If it did not appear he cut the cornea away with scissors. A dose of laudanum was then given and a linseed poultice applied upon which usually the cap was de-

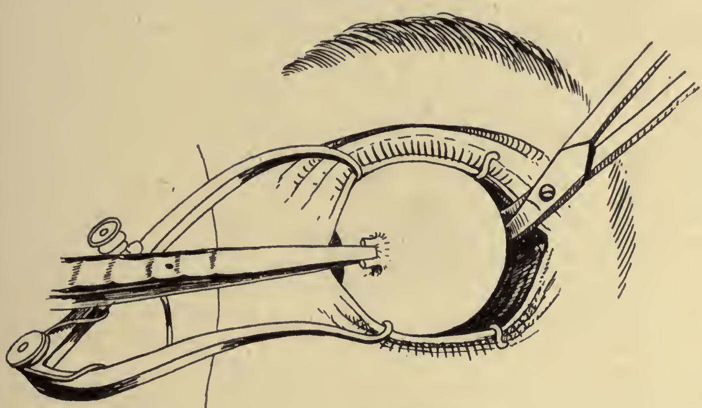

Fig. 235.
Enucleation of the Globe. Vienna Method. The Forceps, with its Firm Grasp of the Internal Rectus Muscle is strongly Rotating the Eyeball towards the External Canthus, while the Strong, Curved Scissors are Severing the Optic Nerve.

posited. Mackenzie recommended this practice in diseased eyes, where vision is lost and when the other eye appears to be in danger. These views were also entertained by Beer.[93]

Abscission of the cornea was proposed by Saint Ives[94], Guerin[95] and Heister[96] in the 18th century, later by Critchett[97], (1863) and was partially described by Wilde in 1847. Critchett made a semicircular-

[92]Mackenzie. *A Practical Treatise on the Diseases of the Eye*, 1834, p. 411.
[93]James Beer. *Graefe-Saemisch Handbuch*, Vol. 3, p. 376.
[94]St. Ives. Beard. *Ophthalmic Surgery*, p. 417.
[95]Guerin. Beard. *Ophthalmic Surgery*, p. 417.
[96]Heister. Beard. *Ophthalmic Surgery*, p. 417.
[97]Critchett, Sr. On the Operation of Abscission in Staphyloma. *Royal Lond. Oph. Hosp. Reports*, Vol. 4, p. 1, 1863.

corneal incision with a Beer's knife and completed the amputation with scissors. The iris and lens were removed, but everything else was allowed to remain. Before incising the cornea, he inserted a few sutures back of the sclero-corneal junction through the ciliary region, and these sutures were tied after the cornea was abscised, leaving the vitreous humor within the scleral walls. Some cases did well and a fine stump was produced, but as the sutures passed through the ciliary region, cases of sympathetic ophthalmia occurred in the practice of Carter[98] and others, which brought the operation into disfavor.

Critchett[99] also operated by passing three curved needles, armed with sutures, through the sclera above and below the cornea, a little back of the area to be removed. The needles were left in position until an elliptical segment of the eyeball was cut out with knife and scissors. The segment included the cornea, iris, lens and some sclera.

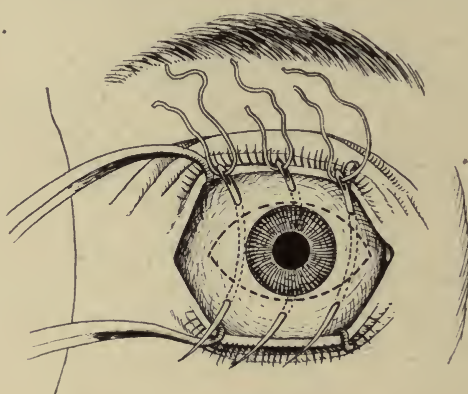

Fig. 236.
Abscission. Critchett's Method. The Needles are in Position. Showing Portion of the Eyeball to be Removed.

The needles hindered the escape of vitreous. After the amputation had occurred, the needles were drawn through and the wound was closed by tying the sutures.

Lagrange[100] modified the operation by making, first, the regular sclero-corneal incision and exposing the recti muscles, each one of which was secured with a suture before being severed. A purse-string suture was then passed around the conjunctival opening. Amputation of the anterior portion of the globe followed, after which the superior and inferior recti muscles were tied together and then the internal and

[98] B. Carter. On an Improved Method of Abscission. Trans. *Medico-Chir. Soc.*, London, 1876, p. 193.
[99] Critchett, Sr. On the Operation of Abscission in Staphyloma. *Royal Lond. Oph. Hosp. Reports*, Vol. 4, 1863, p. 1.
[100] F. Lagrange. Grimsdale and Brewerton, *Ophthalmic Operations*, p. 174.

external recti muscles. The purse-string suture was then tied and the operation completed.

Chevallereau[101] operated by completely incising the cornea transversely. Iris forceps were then introduced into the opening and the iris completely removed. The capsule of the lens was then opened by a cystotome, the lens evacuated and a pressure bandage applied.

Knapp (*Archiv f. Ophthalmologie,* XIV, I. p. 275) modified Critchett's plans by inserting the sutures into the conjunctiva (after abscission), from which delicate membrane they frequently escaped before the scleral opening was united. Knapp and de Wecker[102] often closed the opening with a purse-string suture.

. In 1872 Noyes[103] advocated evisceration in panophthalmitis, an opinion which he reiterated in his text-book of 1881. Noyes' first

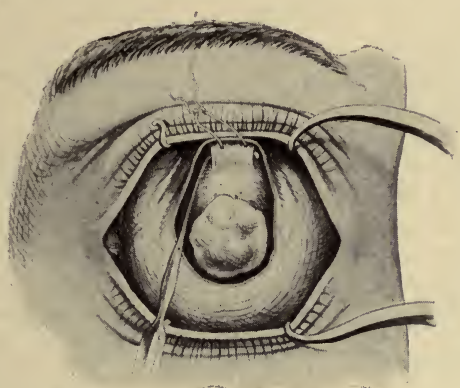

Fig. 237.

Abscission. Method of Lagrange. The Circumcorneal Incision has been Made, the Tendon Raised on the Hook, and the Suture Passed through the Tendon.

operation consisted merely in incising the cornea and thoroughly wiping out the contents of the eyeball.

Williams[104] reported, in 1878, a case where he intended to do an abscission, but upon opening the eyeball a large bony or calcareous shell was found, which he removed, together with all the contents of the eyeball before suturing the scleral opening.

In 1878 Williams read a paper before the American Ophthalmological Society advocating the scooping out of the contents of sloughing

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[101]A. Chevallereau. La Keratotomie Transversale. *Bull. et Mém. de la Soc. Franç. d'Ophtal.*, Vol. 22, 1905, p. 225.

[102]L. de Wecker. *Therapeutique oculaire*, 1879, p. 512.

[103]H. D. Noyes. *Graefe-Saemisch Handbuch*, and Trans. *Am. Ophthal. Soc.*, 1872.

[104]H. W. Williams. Extirpation of the Ossified Choroid Without Enucleation of the Eyeball. *Trans. Am. Ophthal. Soc.*, 1878, p. 406.

globes before the scleral sutures were applied, believing it to be the best method of preventing sympathetic ophthalmia.

H. W. Williams[105] inserted (after abscission) very fine sutures, threaded upon small needles, into the outer layers of the sclera, without passing through the ciliary region. This modification proved quite successful and has been extensively used for staphyloma, etc., as well as in other cases where enucleation was not made.

Carter[106] recommended passing the sutures through the muscles and conjunctiva.

Fröhlich[107], in 1880, reported a case of abscission, with complete evisceration of the scleral contents, followed by suturing of the scleral opening, where the result was excellent.

E. G. Alcorn[108], in 1883, advocated evisceration, which he called

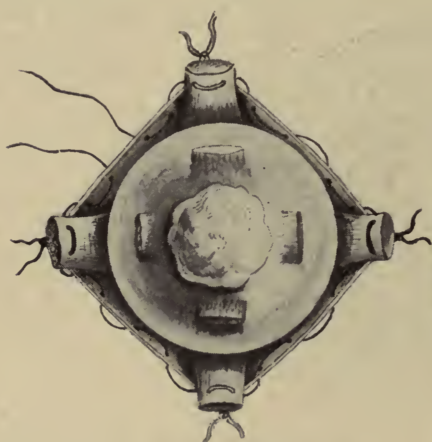

Fig. 238.
Abscission. Method of Lagrange. Diagram Showing the Muscles all Sutured, and the Purse-string Suture Applied.

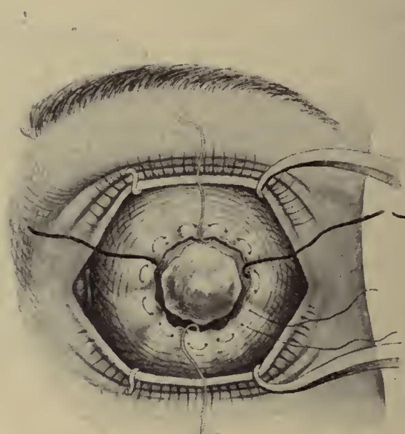

Fig. 239.
Abscission. Method of Lagrange. Showing the Purse-string Suture and the Sutures Holding the Muscles Protruding from the Opening.

"Corneotomy," and was evidently under the impression that he was advancing a new operation.

Then followed, in 1884, Graefe's[109] classical paper on complete

[105]H. W. Williams. *Diagnosis and Treatment of Diseases of the Eye*, 1881, p. 121.

[106]B. Carter. On an Improved Method of Abscission. *Trans. Medico-Chir. Soc.*, London, 1876, p. 193.

[107]C. Fröhlich. Ueber Antisepsis bei Augen-Operationen. *Klin. Monats. f. Augenheil.*, Vol. 19, 1880, p. 30.

[108]E. G. Alcorn. Report on Ophthalmology. *Ohio Valley Med. Assn.*, May, 1883.

[109]A. Graefe. Exenteratio sive Evisceratio Bulbi. *Versam. Deutsch. Naturforscher und Aerzte*, Sept., 1884.

evisceration which he formally puts forward as a tried operation in most cases superior to enucleation.

In 1886 J. L. Thompson[110] first introduced sutures and then, before removing a staphyloma, divided the tendons of the superior and inferior recti muscles in order to relieve the stump of their traction, hoping thereby to allow the lips of the scleral opening to come together easily and thus promote speedier and better healing.

In 1887 Chibret[111] freely opened the cornea and the lenticular capsule, extracted the lens, removed the iris, and evacuated the contents of the globe by repeatedly irrigating the inside of the eye with bi-chloride solution 1:2000. He then packed the eye with cotton soaked with an ointment of iodoform and cocain. The irrigating and packing were repeated a number of times from day to day until healing occurred. He claimed good results.

In 1898 Panas[112] proclaimed himself an earnest advocate of abscission or keratectomy, saying that he had practically abandoned

Fig. 240.
Abscission. Method of Lagrange. The Relative Positions of the Sutures.

enucleation operations; in panophthalmitis, however, he eviscerated. He performed keratectomy as follows:

"The patient being anesthetized, a speculum is introduced between the lids. The eyeball is seized with a fixation forceps. A half-curved Reverdin's needle is then passed through the sclero-corneal junction back of the iris and the crystalline lens, and is made to come out of the eyeball at the opposite sclero-corneal junction. The needle, which is to remain in situ until the last stages of the operation, is next threaded. By means of a von Graefe knife, introduced at the point of union of the transparent and the semi-opaque portions of the cornea, the cornea is freed throughout for about four-fifths of its circumference. The keratectomy is completed by a couple of strokes of the scissors.

"In case the iris has not been detached with the cornea it is seized with a pair of forceps and is removed. The speculum is next gently raised away from the globe and the lens is removed with a scoop. The wound is closed by withdrawing the Reverdin needle armed with its thread and this suture

[110]J. L. Thompson. Operation for Staphyloma. *St. Louis Courier of Medicine*, Vol. 15, 1886, p. 111.

[111]Chibret. Curettage de l'Oeil. *Bull. ct Mém. de la Soc. Franç. d'Ophtal.*, 1892, p. 297.

[112]P. Panas. Total Combined Keratectomy. *Arch. d'Ophtal.*, Sept.; 1898.

is reinforced by one on each side. To complete the operation the projecting angles of the wound are trimmed off with scissors. As a rule there should be no hemorrhage. A one to twenty thousand strength solution of biniodide of mercury is used to cleanse the wound. The stump is dusted with iodoform and a dry dressing with a layer of iodoform gauze is placed next to the lids. At the end of three days the dressing is changed, and four days later the sutures are removed."

In 1899 Bourgeois[113] proposed an incision with a Graefe knife two or three mm. back of the corneal limbus, chiefly to avoid the ciliary region. He then closed the opening with three sutures.

The stump in this operation is not large, but it is healthy and heals quickly. He applied the operation in total corneal staphyloma, absolute glaucoma, severe corneal burns, severe traumatism where vision is lost and sometimes in anteriorly situated malignant tumors. His view of the last indication is certainly not shared by many surgeons.

In 1906 Fage[114], in endeavoring to mitigate some of the objectionable features of abscission as noted by previous surgeons, proposed the following operation:—

"The conjunctiva is dissected up all around the limbus. The cornea is then incised transversely with a Graefe knife. A fine catgut thread armed with two needles is passed through the cornea from within outward, to avoid pressure on the vitreous, and the necessary portion of the cornea is excised, leaving two flaps adherent to the limbus. The lens is removed, after incising its capsule and, if necessary, the iris also. The thread is then tied and reinforced with two or three others, and the conjunctiva is drawn over the cornea and sutured, as has been recommended in accidental wounds. At the end of eight days the latter sutures are removed and the conjunctiva retracts, leaving the cornea uncovered. Later the cornea is tattooed to imitate a pupil."

Objections to Abscission.

Poncet[115], Suker[116], R. Derby[117], Priestley Smith[118], Treacher Collins[119], Knapp[120] and others have noticed irritable stumps following abscission, necessitating removal of the eyeball. Others have noted, as objections to abscission, sympathetic irritation and ophthalmia, loss of vitreous, scleral contraction, etc., and it is quite generally conceded that if the operation has any place in ophthalmic surgery at all, its use should be limited to non-inflamed staphylomatous eyes, especially in

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[113] A. Bourgeois. Amputation of the Anterior Section of the Eye. Trans. from *Recueil d'Ophtal.*, April, 1899.

[114] A. Fage. Keratectomy with Flaps. Trans. from *Arch. d'Ophtal.*, July, 1906.

[115] F. Poncet. *Trans. Oph. Soc. of U. K.*, 1898. Committee Report.

[116] Geo. F. Suker. The Comparative Value of Enucleation and the Operations which have been Substituted for It. Committee Report. *Trans International Oph. Congrcss*, 1900. p. 2.

[117] R. Derby. *Trans. International Oph. Congress*, 1900. Committee Report.

[118] Priestley Smith. *Trans. Oph. Soc. of U. K.*, 1898. Committee Report.

[119] Treacher Collins. *Trans. Oph. Soc. of U. K.*, 1898. Committee Report.

[120] H. Knapp. *System of Diseases of the Eye*, Norris and Oliver, Vol. 3, p. 831.

children, and possibly in megalophthalmos. Harlan's writings, however, show an enthusiastic allegiance to the operation.

Rogman[121], in 1903, issued a warning against enucleation in tuberculous eyeballs, as he had observed several fatalities (especially meningitis) following this operation. He believes that evisceration is to be preferred and, in advanced cases, exenteration of the entire orbit.

Final State of the Eyeball after Evisceration.

In the modern operation for evisceration the sclera with its muscular attachments is left intact and it was believed by its advocates that this would leave an especially good, prominent and movable stump. Such claims are undoubtedly primarily true, but in course of time the scleral shell atrophies to such an extent, and the optic nerve pulls the sclera, muscles, conjunctiva, etc., so far back into the socket that the ultimate cosmetic effect of the stump is no better, in my judgment, and perhaps not as good as that of any good enucleation where the muscles and conjunctiva are gathered together.

Estimates of ocular movement, as between enucleation and evisceration, as observed by Hotz[122], Truc[123] and de Schweinitz[124], fortify this assertion. Besides this cases of sympathetic ophthalmia have been reported by Dransart[125], Van Duyse[126], Forget[127], Nieden[128], de Wecker[129] and others, following this operation and it is not at the present time a favorite surgical procedure, especially since it was quite generally condemned at the Heidelberg Ophthalmological Congress of 1908.

H. Knapp[130] practised evisceration until 1883, when he (as has
Cellulitis. *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 309.
already been mentioned) observed a severe case of orbital cellulitis and thrombosis following the operation, after which he practically abandoned the procedure. Shieck[131], Hotz[132], Schmidt-Rimpler[133], de Schweinitz, Waldispühl and others have reported instances of sympathetic ophthalmia following evisceration where investigation showed

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[121]M. Rogman. Intraocular Tuberculosis and the Dangers of Enucleation. *Trans. from Ann. d'Oculist.*, Nov., 1903, Vol. 130, p. 349.

[122]F. C. Hotz. *International Oph. Congress.* Committee Report. 1900.

[123]H. Truc. *Internat. Congress.* Committee Report, 1900.

[124]G. E. de Schweinitz. *Internat. Congress*, 1900. Committee Report.

[125]Dransart. Beard. *Ophthalmic Surgery*, 1910, p. 465.

[126]Van Duyse. Beard. *Ophthalmic Surgery*, 1910, p. 465.

[127]Forget. *Arch. d'Ophtal.*, Vol. 12, 1892, p. 693.

[128]A. Nieden. Beard. *Ophthalmic Surgery*, 1910, p. 465.

[129]L. de Wecker. Beard. *Ophthalmic Surgery*, 1910, p. 465.

[130]H. Knapp. A Case of Evisceration of the Eyeball Followed by Orbital

[131]Shieck. Bietet die Extenteratio Bulbi einen hinreichenden Schutz gegen den eintritt der Sympathischen Ophthalmie? *Bericht der Ophthal. Gesell.*, 1908, p. 355.

[132]Hotz. *Internat. Oph. Congress*, 1900. Committee Report.

[133]Schmidt-Rimpler. *Internat. Oph. Congress*, 1900. Committee Report. G. E. de Schweinitz.

fragments of uveal tissue (left after the operation) lining the sclera. These shreds contained structures liable to produce sympathetic ophthalmia, and because of this and other objections evisceration is regarded as an unsafe operation. Such opinions as the foregoing, however, are not shared by every one, since Gifford[134], Henderson[135] and others regard evisceration as a safer operation than enucleation. They feel that in panophthalmitis fewer avenues of infection are opened in evisceration and that in all cases, inasmuch as in this operation the optic and ciliary nerves are not cut, the danger of sympathetic ophthalmia is much less. It must be admitted that these are good arguments and that the question is still unsettled.

Evisceration is employed by some surgeons in preference to enucleation in cases of panophthalmitis, where it is deemed dangerous to cut the optic nerve for fear of opening up a surgical pathway of infection from the eye to the brain, with the possible production of a meningitis.

This fear is not by any means groundless, as indubitable records such as those of Hobby[136] in 1886, Delibes[137] in 1898, Graefe[138], Risley in 1893, Siffre[139] in 1889, Enslin[140] and Kuwahara in 1904, Nettleship[141], Coppez, Panas and others prove that meningitis sometimes follows enucleation, especially (but not solely) if this operation occurs during the existence of acute suppurative panophthalmitis.

Randolph, in an article upon The Question of Enucleation in Purulent Panophthalmitis, appearing in the *Jour. Am. Med. Assoc.*, June 18, 1910, reports experiments made on 43 rabbits. He produced a purulent panophthalmitis in one eye and then removed it. No meningitis was produced in any case. Nevertheless, Randolph prefers not to enucleate a panophthalmitic eye. He prefers deep incisions into the eye on each side of the cornea.

In the discussion which followed the reading of this paper Fox, Kipp, Taylor, Ledbetter, Ellett, Ziegler and Jackson advocated enucleations during panophthalmitis.

Nor is meningitis the only serious consequence that may follow

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[134]Gifford. On Strictly Simple Evisceration. *Arch. of Ophthal.*, July, 1900, p. 422.

[135]Henderson. Enucleation or Evisceration? *Am. Journ. Ophthal.*, Jan., 1908.

[136]Hobby. Enucleation in Panophthalmitis. *Am. Journ. Ophthal.*, 1886, p. 141.

[137]Delibes. Un cas de mort après Enucleation pour Panophtalmie. *La Clinique Ophtal.*, July 25, 1898, p. 161.

[138]Graefe. Enucleation oder Exenteratio Bulbi. *Centralb. f. pkt. Augenheilk.*, Dec., 1884, p. 378.

[139]Siffre. Thesis of 1889. (Article by Rohmer.) *Ann. d'Oculist.*, April, 1892, No. 13.

[140]Enslin and Kuwahara. *Arch. f. Augenheilk.*, Sept., 1904.

[141]Nettleship. Meningitis after Excision of the Globe. *Trans. Ophthal. Soc. of U. K.*, 1886, p. 445.

panophthalmitis for, contrary to the belief entertained by some surgeons that sympathetic inflammation of the opposite eye does not follow panophthalmitis in the other, Ahlström, Schirmer[142] and Würdemann report cases where this unfortunate termination has occurred. These cases seem to contradict the theory of Leber[143] and Deutschmann that the panophthalmitis inflammation stopped up the lymph passages and prevented germ migration, and the theory of Gifford[144] that the infiltration of the pus corpuscles in the optic lymph spaces prevents bacterial invasion of the sound eye.

Cavernous sinus thrombosis has been known to follow enucleations, etc., as noted by Nettleship[145] and others.

THE OPERATION OF EVISCERATION.

After the insertion of the speculum the conjunctiva is firmly grasped by the forceps and a large Beer's knife is inserted (from the

Fig. 241.
Abscission. Method of Lagrange. Front View of the Closed Wound.

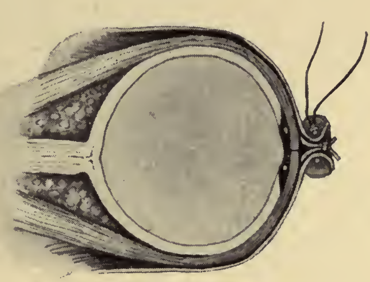

Fig. 242.
Abscission. Method of Lagrange. Profile View of the Closed Wound.

temporal side) into the eyeball just back of the (posterior to the iris) sclero-corneal junction. The knife is pushed through the eyeball to the other side, thus transfixing the globe upon the blade of the knife. The half-section of the eyeball is completed by the knife and the other half of the anterior section of the globe is grasped by forceps and cut away with scissors, thus completely exposing the interior of the bulb to view. The upper section is usually made first by the knife

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[142]Schirmer. Sympathische Augenerkrankung. *Graefe-Saemisch Handbuch*, 1900, pp. 23 and 25.

[143]Leber and Deutschmann. Ueber die Blendung der Netzhaut durch directes Sonnenlicht. *Arch. f. Ophthal.*, Vol. 28, Part 3, p. 241.

[144]Gifford. Clinical and Pathological Notes on Sympathetic Ophthalmia. *Jour. Am. Med. Assn.*, Feb. 10, 1900, p. 341.

[145]Nettleship. Intra-Cranial Affections. *Trans. Oph. Soc. of U. K.*, 1886, Vol. 6, p. 445.

and the lower section completed with the scissors, but this can, of course, be reversed if desirable.

The entire contents of the eyeball are now removed by a sharp and rather large spoon curette, by the scoop recommended by Fox, by the exenteration spatula of Beard, or by firm gauze sponges held in forceps as recommended by Voorheis. One must be careful to scrape away *everything down to the bare sclera.* Should the intra-scleral hemorrhage be troublesome it may be controlled by hot bichloride tampons, adrenalized tampons or pressure applied firmly to the posterior wall of the scleral sac.

The interior of the eye should now be cauterized by carbolic acid,

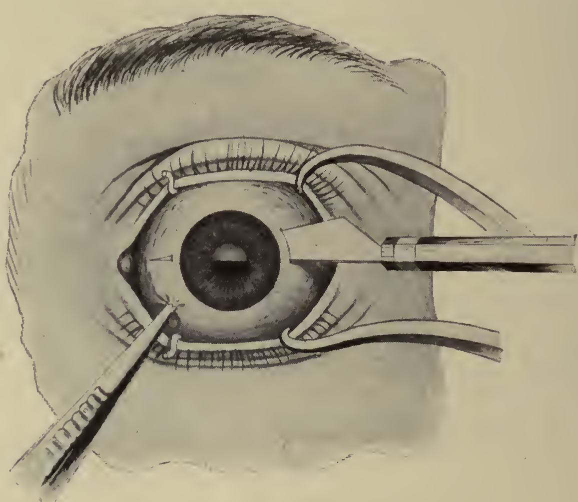

Fig. 243.
Abscission. Showing Beer's Knife in Position.

which must be quickly neutralized by alcohol. This application, suggested by Prince[146] (1888) not only mitigates the pain following the operation, but strongly sterilizes the scleral interior. It forms, as Prince says, a coagulum which closes the vascular openings in the sclera and lessens the tendency to microbic invasion backwards. The carbolic acid is applied by a large tuft of cotton wound on a cotton holder, the alcohol may be poured in with an eye-dropper and then dried out by cotton or gauze. The scleral and conjunctival openings should be sewed together with the interrupted or purse-string suture, and the operation is finished.

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[146]Prince. Pain Following Evisceration Modified by Cauterizing the Interior of the Sclera with Carbolic Acid. *Am. Journ. Ophthal.*, July, 1888.

Gifford[147] (1900) performs what he calls a "strictly simple evisceration of the eyeball." He describes his operation as follows:

"A conjunctival flap is laid back by two incisions, one along the corneal margin from near the insertion of the external rectus to that of the superior rectus, the other extending from the lower extremity of the incision obliquely upward back to the retro-tarsal fold. A meridional incision ¾-inch long is then made through the sclera midway between the external and superior recti, extending from within 3 mm. of the corneal margin toward the posterior pole of the eye; the eye then being turned down, the contents of the globe are scraped out through this incision, which is held apart with hooks or forceps. The conjunctival flap is then replaced by two or three sutures, no scleral sutures being employed. The advantages of this operation are that, although the stump gradually diminished in size until the cornea is reduced to a mere facet, on the average a much larger stump is finally obtained than where an evisceration plus a keratotomy without the introduction of any foreign body is done.

"Another advantage of the simple operation is the reduction of the conjunctival edema which is so frequently an unpleasant feature of the cur-

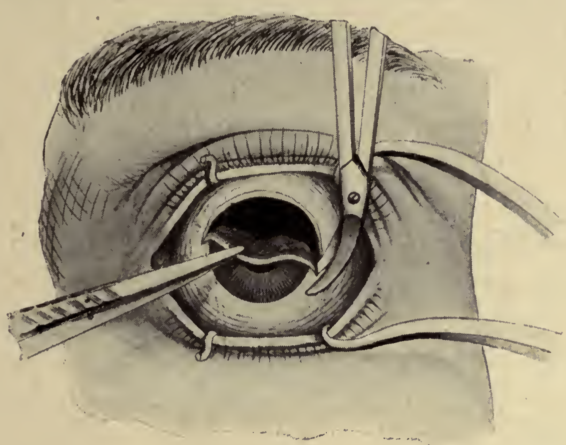

Fig. 244.
Abscission. Removing the Lower Flap with Scissors.

rent operation. After the simple evisceration there is in most cases no chemosis worth mentioning. The disadvantage is that it is more difficult to remove the contents thoroughly and to obtain a view of the interior than where the cornea is cut out."

To obviate this difficulty Gifford has somewhat modified his operation, as follows:—

"The incision is either carried clear across the centre of the cornea and ⅛-inch into the sclera on either side and after evisceration no suture introduced; or the incision extended from the centre of the cornea back as far into the sclera as might be required, a single conjunctival suture at the edge of the cornea being put in; or a scleral flap is made with one branch of the incision partly surrounding the cornea at a short distance back of it, the other a meridional scleral incision, scleral and conjunctival sutures being introduced. In two cases where scleral and conjunctival incisions were made, the edges were held in more or less complete apposition by the

[147]Gifford. On Strictly Simple Evisceration of the Eyeball. *Arch. of Ophthal.*, July, 1900.

application of the ordinary purse-string conjunctival suture. The important point is that the cornea is retained."

Gifford[148] has further modified his operation by making a broad, horizontal cut across the cornea and into the sclera for ¼ inch on either side.

The contents of the globe are then eviscerated by vigorous wipings with gauze swabs, wound on forceps. After irrigation, a large aristol-saturated gauze pad is pressed on the eye to flatten it out and produce a good stump. No sutures are used and a firm bandage is worn for several days.

Voorheis[149] and Ahlstöm[150] have advocated a similar operation. Ahlström uses no sutures. He has sometimes combined this procedure with the introduction of an artificial vitreous with good results. He claims that the cornea becomes insensitive and that Mules' globes are not so likely to escape on account of the presence of an intact or comparatively intact cornea.

Chevallereau[151] tried the operation in 1900, but abandoned it on account of the small stump obtained. This experience is contrary to that of Gifford.

Fig. 245.
Evisceration Scoop Used in Evisceration or Mules' Operation.

Beard[152] proposes to make the incision in Gifford's operation vertical instead of horizontal, which makes, he thinks, a better and a more mobile stump.

Cautery Methods in Evisceration.

Lapersonne,[153] in 1900, proposed another method of operating for evisceration, which he uses particularly in cases of panophthalmitis and where the sclera threatens to rupture. The cornea is incised with a Graefe knife and the incision is enlarged up and down with scissors. The cornea is not removed. The lens is now extracted, after which a large cautery knife at white heat is introduced within the ocular cavity and passed all around the circumference.

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[148]Gifford. Personal Communication, 1910.

[149]Voorheis. *Internat. Oph. Congress*, 1900. Committee Report.

[150]Ahlström. Grimsdale and Brewerton, *Ophthalmic Operations*, p. 178.

[151]Chevallereau. Operation de Critchett et Ophtalmie Sympathique. *Rec. d'Ophtal.*, April, 1900, p. 210.

[152]Beard. *Ophthalmic Surgery*, 1910, p. 413.

[153]Lapersonne. De l'Exenteration ignée. *Arch. d'Ophtal.*, Vol. 1, Jan., 1901. p. 4. Also, L'Exenteration ignée dans la Panophtalmie, *Arch. d'Ophtal.*, June, 1900, p. 289.

"A small cautery knife is sufficient but the large one in use in general surgery is by far the best, and this knife should be curved, its convexity corresponding about to that of the eyeball. When the cautery is withdrawn, it is usually covered with the contents of the eyeball, and purulent debris. It is then reintroduced at a white heat and the sclera thoroughly cleansed. The operation is concluded by washing out the globe with sublimate, not so much for the purpose of antisepsis, as for the special object of removing charred tissue left behind. No suture is necessary. The opening is covered with iodoform and dressed with a simple bandage. In this way not a drop of blood is lost. All vascular tissue is charred and adheres to the cautery knife. The immediate effect of this procedure is an absolute cessation of all pain. It is marvelous to see how these patients, after recovering from the chloroform, express their gratitude at the relief from the terrible agony which was suffered before the operation, a great contrast to the usual method of operation in which the pain remains for some time afterward. The secretion continues for three or four days and it is therefore necessary to renew the bandage about twice a day. The swelling of the lips of the wound diminishes rapidly and after ten or more days the cicatrix is complete. The stump is regular but small, and the remains of the cornea can still be detected, but there is no pain in the stump and the artificial eye can soon be inserted, the movements of which, in his experience, are much more natural than after the ordinary operation."

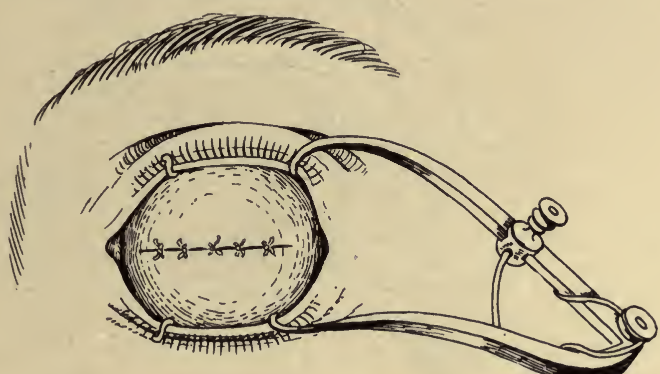

Fig. 246.
Abscission or Evisceration. Showing Closure of Wound.

Dianoux *(Annal. d'Oculist., Vol. CXXVII)* suggests another cautery operation for anterior staphyloma in children. He draws, with the cautery at dull heat, a star on the cornea, the incisions nearly but not quite perforating the cornea. He then makes (also with the cautery) a circular perforation in the cornea which evacuates the aqueous humor. He then dresses the cornea with bismuth powder and applies a compress bandage. Tattooing the eye, after irritation has subsided, completes the procedure.

Schmidt-Rimpler[154] in 1900, in drawing some deductions from a large number of eyeball removals, etc., performed at his clinic, concluded that healing was quickest after enucleation and longest after optico-ciliary neurotomy. Sympathetic inflammation subsided after

[154]Schmidt-Rimpler. Enucleation and Its Substitutes. Trans. from *Deutsch. Med. Wochenschr.*, No. 27, 1900, p. 429.

enucleation in four of his cases and in five instances the eye was lost. In some cases sympathetic ophthalmia occurred three or four weeks after enucleation, even later after neurotomy or neurectomy, and after exenteration within the first week. He concludes that enucleation is the safest operation for the prevention of sympathetic ophthalmia. In a few cases he was compelled to resort to it after performing exenteration or optico-ciliary neurectomy on account of pain. He thinks that exenteration is always indicated in suppurative choroiditis as fatal cases of meningitis have followed enucleation, although he has never seen one.

It should not be forgotten that sloughing of the sclera has been observed after evisceration by Albini,[155] Treacher Collins[156] and others, and that the operation is rather apt to be followed by more reaction and

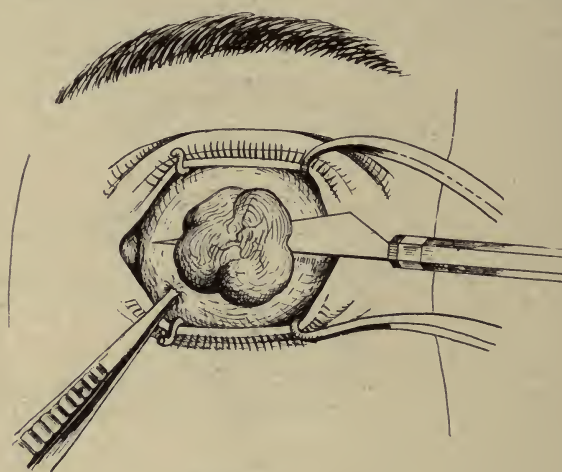

Fig. 247.
Incision for Removal of a Staphyloma.

by a little longer stay in the hospital than where an excision has been performed. The stump may also be somewhat painful and irritable.

MULES' OPERATION.

The operation of evisceration combined with the transplanting of a hollow globe in the scleral sac, devised by Mules in 1885, is one of the most interesting procedures in the whole range of ophthalmic surgery. It is performed as follows: The fullest aseptic and antiseptic precautions must be observed during all the steps of the operations.

The evisceration is performed exactly as has just been described,

[155]Albini. *Trans. Oph. Soc. U. K.*, 1898, p. 258, Committee Report.

[156]Treacher Collins. *Trans. Ophthal. Soc. U. K.*, Committee Report, 1898, p. 271.

with the exception that in Mules' operation the conjunctiva should be well undermined by scissors as far back as the equator of the globe, being careful not to tear it or to interfere with the muscles. Besides this the optic papilla should be carefully scraped with the curette to a level with the surrounding sclera to prevent irritation of the nerve by the hollow sphere, which is to be transplanted and retained permanently within the scleral sac. Two small, triangular pieces of the sclera are now cut away, that the upper and lower sides of the wound come neatly and evenly together when they are sutured. Unless this precaution is taken, there will be a lump at each end of the sutured opening. Bissell,[157] in 1900, in order to make an adequate opening that could be nicely coapted, proposed to pass a Graefe knife through the eye from one sclero-corneal junction to the other. This

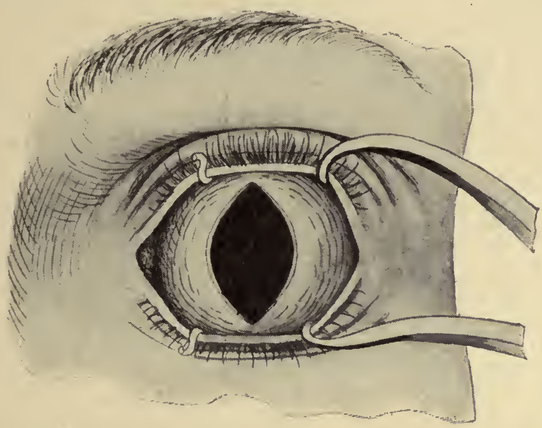

Fig. 248.
Mules' Operation. Removal of Triangular Pieces of Sclera to Facilitate the Accurate Closure of the Opening.

is done in the horizontal meridian and the edge of the blade is then turned directly forwards, and the cornea cut through in the same meridian. This makes a complete incision through the entire width of the cornea. The knife is then passed up beneath the upper corneal flap, and the point brought out through the sclera about 6 or 7 mm. above the cornea and the flap divided in two halves by a forward cut. The same is done to the lower flap. The four triangular flaps are then cut off by scissors, and when the ball is finally placed within the scleral pouch, the incision is brought together with sutures without overlapping, gaping, puckering or tension. This makes, so Bissell claims, a smooth, vertical closure, with satisfactory results.

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[157]Bissell. Mules' Operation. *Trans. Am. Ophthal., Otol & Laryn. Soc.*, 1900, p. 51. Also, *Hom. Eye, Ear & Throat Journ.*, Sept., 1900.

The routine followed by most operators at this point is to insert the hollow globe (after cessation of hemorrhage) into its scleral resting place.

L. Webster Fox[158] severs the recti muscles from and close to the sclera, because he believes that owing to the irritation induced in the neighborhood of the muscles by the operation, great muscular contraction occurs which sometimes pulls apart the sutured scleral opening and allows the expulsion of the ball. He thinks that this is the reason why so many balls have escaped and the operation fallen largely into disuse. He claims that since adopting this method he has retained all balls and that by being careful to include the capsule of Tenon in the conjunctival sutures at the end of the operation, the recti muscles become reattached to the sclera farther back than their original site of attachment which, of course, weakens their power but retains suf-

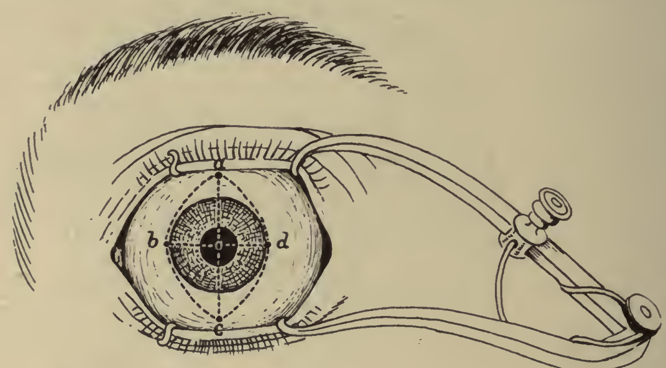

Fig. 249.
Mules' Operation, Bissell's Method of Preparation of the Opening.

ficient strength to freely move the stump in all directions without exerting disastrous traction on the sutured scleral opening.

Fox has had much experience with Mules' operation and his opinion is certainly deserving of great weight, but it does not seem at all certain that the muscular traction is the sole cause of the expulsion of the ball. I have made many of these operations and have had only one ball ejected. My experience leads me to the belief that if the scleral opening is securely closed by numerous, delicate, strong, silk sutures, placed far back in the sclera, so as to guarantee a firm hold; if strict asepsis is observed; if the operation is not made in the presence of a thin or disorganized sclera; and if the ball is not too large, there is little likelihood of an expulsion.

Buller[159] and de Schweinitz[160] do not consider attenuated sclero-

[158]Fox. *Diseases of the Eye*, 1910, p. 527.
[159]Buller. Internat. Oph. Congress, 1900. Committee Report.
[160]de Schweinitz. Internat. Oph. Congress, 1900. Committee Report.

tics, such as seen in buphthalmos for instance, a contra-indication to the operation.

An unfortunate blunder is to select *an overly-large ball,* thinking thereby to secure an increased cosmetic effect. The sclera contracts a great deal after this operation and if a ball is selected which is a "tight fit" the wound will be quite likely to open and permit its escape. The ball should be so small that the sclera wrinkles over it instead of fitting tightly.

Risley[161] and Suker[162] feel, on the other hand, that the selection of too small a ball invites its expulsion. It is difficult to conceive why this should be true, but of course it is not wise to select an extremely small ball, as this would largely defeat the very object of the operation. The ball should be of a size that enables the surgeon without the slightest effort to draw the sides of the scleral opening together over it. The sutures should be easily inserted and the sclera should wrinkle just a little as it envelops the ball. If a small ball be selected and plenty of delicate but strong sutures are used, which are placed far back in the sclera, it will be exceedingly unlikely to escape.

It would also appear that inasmuch as a freely-moving stump is one of the chief arguments in favor of Mules' operation, great pains should be taken to preserve intact the function of the recti muscles, and yet Fox proposes to tenotomize all these muscles and trust largely to the sutures which pass through the conjunctiva and Tenon's capsule to insure their reattachment and restoration of their power. It can easily be conceived that this does not always occur, and when it does not, one of the chief objects of the operation is surrendered. It would also seem much easier (if the muscles are to be tenotomized at all) to sever the tendinous connections either before the evisceration is performed or after the glass ball has been sutured in place, and before the conjunctiva is united, as tenotomies can be more readily performed over a full than a collapsed eyeball.

This question of tenotomy may, however, be settled by each surgeon for himself.

The intra-scleral hemorrhage is given time to cease, hemostasis being facilitated by the application to the interior of the eye of cotton pads soaked in hot bichloride or adrenalin solution, accompanied with pressure. The result is aided by the application of the carbolic acid and alcohol aforementioned.

The next step is the insertion of the hollow ball, care being taken that it is thoroughly aseptic, round without holes and is not too large.

Brundenell Carter[163] in 1891, proposed (for the purpose of arrest-

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[161]Risley. Internat. Oph. Congress, 1900. Committee Report.
[162]Suker. Internat. Oph. Congress, 1900. Committee Report.
[163]Brudenell Carter. *Trans. Med. Soc. of London*, 1891-2, Vol. 15, p. 473.

ing hemorrhage) to fill the scleral cavity with an air-filled India-rubber ball, which is introduced collapsed, and afterwards inflated with air from a syringe. It has not been much used.

Before inserting the sterilized ball, the interior of the scleral sac should be thoroughly irrigated with a bichloride solution; then the ball should be dropped into its permanent resting place, either by the fingers of the operator or by one of the instruments devised for this purpose. The scleral opening should be closed vertically by numerous strong, black, dialyzed sutures, set well back into the sclera, to prevent their pulling through when the subsequent swelling and contraction occur. The sclera is tough and sometimes difficult to perforate with a needle; this difficulty may be greatly overcome by a pair of eyelet-forceps, which steadies both tissues and needle and guides the passage of the latter through the dense sclera. These silk sutures remain permanently in position and become buried under the conjunctiva; they should,

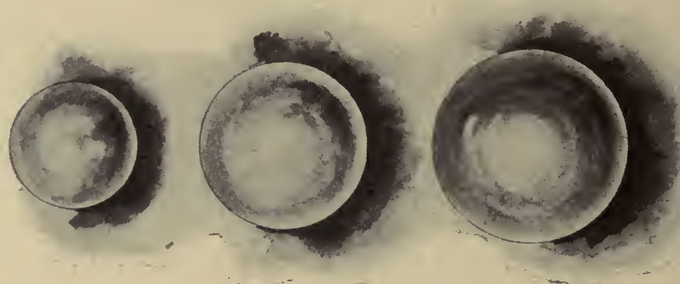

Fig. 250.
Mules' Operation. Showing Different Sizes of Balls.

consequently, be left as smooth as possible and their ends should be cut off as close to the knot as is consistent with safety. They must not be of catgut, as it quickly absorbs; and their continual presence is necessary to keep the scleral opening closed and to resist the traction on the tissues which, if unresisted, would ultimately result in the expulsion of the ball.

The conjunctival opening is now closed horizontally (at right angles to the scleral opening) as by sealing it in this direction the efficacy of the closure is increased. The sutures should be removed in about one week or, in other words, when the conjunctival tissues are firmly united. They should be set well back in the conjunctiva and should include the capsule of Tenon.

Mittendorf[164] recommends suturing the conjunctiva and sclera together at the same time.

[164]Mittendorf. Internat. Oph. Congress, 1900. Committee Report.

Mules has recommended placing a horsehair drain in the orbital tissues, at the end of the operation, hoping thereby to lessen the usual reaction. He cuts the external canthus with scissors, burrows freely into the orbit with sharp, curved scissors and in the opening places the horsehair. Other surgeons do not appear to have followed Mules' suggestion and even he does not lay much emphasis upon it in his later writings.

The operative field is now thoroughly irrigated with a bichloride solution. Considerable reaction and swelling usually occurs after this operation, thus subjecting the tissues to great strain. This edema encourages a loosening of the sutures. To combat this tendency Fox[165] uses what he calls a "conformer," made either of glass or gold-plated silver. It is shaped to the contour of the eye, is either solid or perforated in its center, and acts as a splint to support the sutured scleral and conjunctival wounds. I have used the conformer in a number of cases and can endorse Fox's claims.

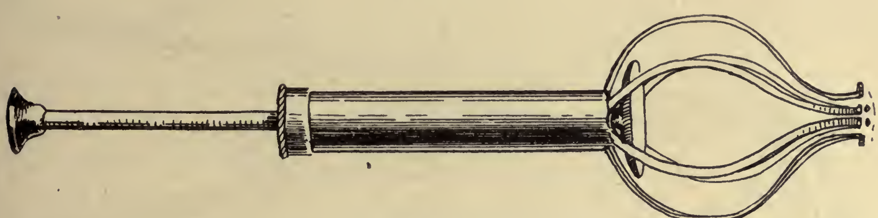

Fig. 251.
Mules' Operation. Instrument for Insertion of the Ball.

The operative area and conformer should be well-dusted with an antiseptic powder, or, what is better, abundantly smeared with a bichloride ointment; if powders are used, the lid margins and lids should be covered with the ointment. A perfectly dry antiseptic dressing is preferred by some surgeons. A pressure bandage is applied over both eyes to support the sutured wounds and promote immobility of the operated eye. It should remain in position for about two days and may be slightly loosened if the pain and swelling are great. It may be necessary to give anodynes and the patient should be kept quietly in bed for the first few days.

Fever sometimes occurs and Mules,[166] Frost[167] and Bickerton[168] have seen cases of scleral sloughing.

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[165]Fox. Implanation of a Glass Ball. *New York Med. Journ.*, Jan. 18, 1902.

[166]Mules. *Trans. Ophthal. Soc. U. K.*, 1898. Committee Report. p. 261.

[167]Frost. *Trans. Ophthal. Soc. U. K.*, 1898. Committee Report, p. 261.

[168]Bickerton. The Operative Treatment of Injured or Painful Blind Eyes. *Med. Times and Gazette*, May 1, 8, 15, 1897.

The stay of the patient in hospital is somewhat longer than after an enucleation.

In rare cases the stump after a Mules' operation becomes painful and in some instances enucleation to relieve this pain is necessary. Folker and Richardson Cross have reported such cases. Excessive vomiting sometimes occurs and is attributed by Bickerton to traction upon the optic nerve.

The bandage may be removed in about two days, and the conformer in three or four days, but the stitches should not be removed for about a week as the conjunctival wound is apt to gape if the sutures are removed too soon. Stitch abscesses are infrequent, but if they occur the stitches should, of course, be removed.

It has been said that the bandage may be removed in two days,

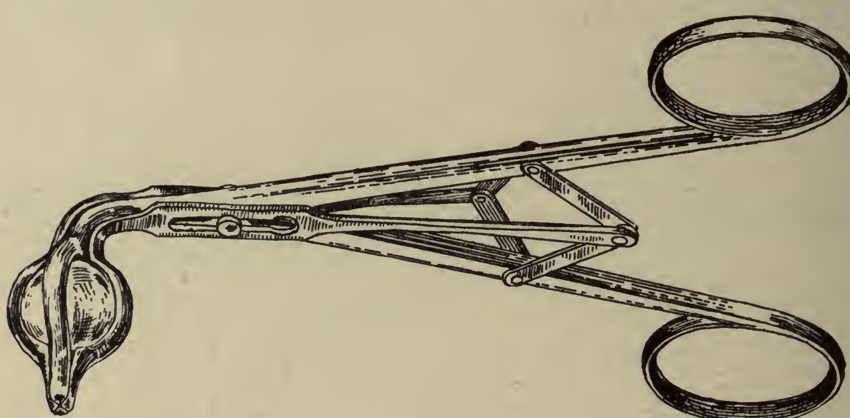

Fig. 252.
Mules' Operation. Instrument for Insertion of the Ball.

but this is merely for the purpose of thoroughly cleansing the parts, inspecting them, applying fresh powders or ointments (or both) and placing a firm pressure bandage again over both eyes.

There is usually some reaction and swelling following this operation and the sutures need to be supported until they are removed, after which time the bandage can generally be permanently removed. If the reaction is marked ice packs may be applied over the bandage for several hours a day, or, as Fox[169] recommends, the following lotion may be poured both upon the ice and the bandage over the eye operated on, which ought to be kept constantly moist with this iced antiphlogistic:

[169]Fox. *Diseases of the Eye*. 1910.

℞

Liq. plumb. subacet. dilut.	℥ ii
Tr. opii.	
Tr. belladon. āā	℥ ss
Tr. arnicæ	℥ ii
Aq. camphor.	
Aq. destill. āā q. s. ad.	℥ iv

Bickerton *(British Med. Jour.* Sept. 26th, 1896) claims to have largely done away with the after-pains and swelling by the abolition of a pressure bandage and by the almost constant application of iced saline packs over the closed lids.

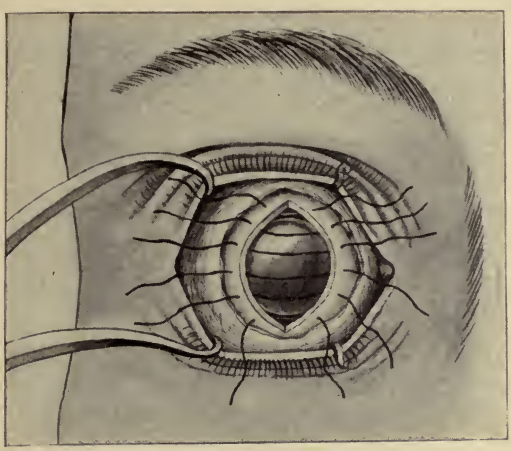

Fig. 253.

Mules' Operation. Showing the Ball in Place and the Scleral Sutures in Position.

Prothesis in Mules' Operation.

The artificial eye should not be adjusted for at least one month after the operation.

Fox[170] has devised artificial eyes for use after the Mules and other similar operations "having a cup-shaped depression on their posterior surface" which comes in contact with the prominence produced by the ball and is held in place by suction. They are manufactured by Wall and Ochs, of Philadelphia.

So far as cosmetic results are concerned, this operation is unequalled, and when its advantages are considered, such as life-like appearance, mobility of the prothesis, flow of natural secretions over the shell (directed into proper channels instead of overflowing on the

[170]Fox. *Diseases of the Eye,* 1910.

lids), lack of enophthalmus and the maintenance of the physiological orbital development, leaves little to be desired.

Drawbacks of Mules' Operation.

If certain objections to its use could be overcome, the operation would be much more generally adopted, especially in individuals where personal appearance is highly important. The idea prevails that very few balls remain in situ, but this is only true where the operation is poorly performed; if done in accordance with the directions set forth in this chapter, very few balls will be expelled. If balls are expelled, it occurs in a short time after the operation, although instances of extrusion some years after are on record. If even a small opening occurs at the line of suture, exposing the ball, its total expulsion is

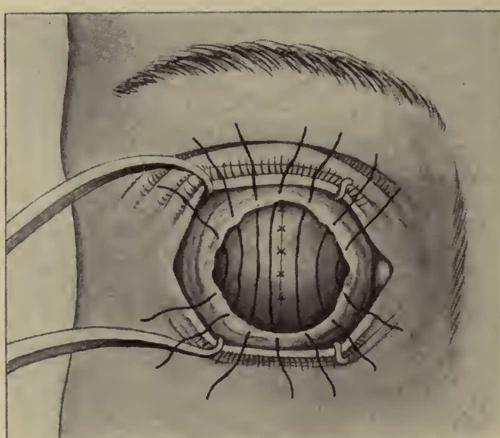

Fig. 254.
Mules' Operation. Scleral and Conjunctival Sutures in Position.

inevitable if the ball is of some hard material like glass or gold. If it is, for instance, of paraffin, it can be taken care of, as will later be described, but, if it is of glass, gold, etc., an entirely different procedure must be instituted. In the latter case no success has followed refreshening of the edges of the opening and resuturing of the parts.

Juler reported one successful case in which he pared the edges of the aperture and grafted on a piece of the patient's lip.

Mules[171] reported two successful cases and Lang[172] one where they removed the sphere, refreshened the edges of the aperture, inserted a smaller globe and resutured the wound.

Should the globe escape, however, the most practical procedure

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[171]Mules. *Trans. Ophthal. Soc. U. K.*, 1898. Committee Report.
[172]Lang. *Trans. Ophthal. Soc. U. K.*, 1898. Committee Report.

is to convert the operation into one of simple evisceration by cleansing the interior of the scleral sac, cauterizing it with carbolic acid, after the manner of Prince, freshening the edges of the aperture and suturing the opening with catgut.

To combat the expulsive tendency of the ball, Grimsdale and Brewerton,[173] in 1907, proposed that the cornea should not be amputated, but that a long, curved incision should be made in the sclera just above the cornea, through which the evisceration should be made. After this the ball is inserted and the sclera sutured. They report good results and feel that the strain upon the sutures (especially the central suture) is much less than in the other way of operating.

J. J. Thomson[174] wrote me in 1909 that his method of suturing the sclera is as follows:—"Instead of drawing the smooth, glossy and

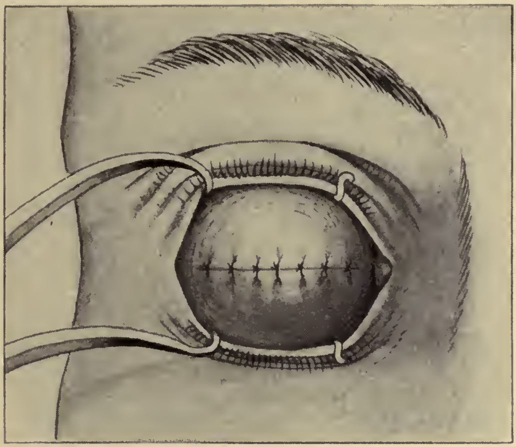

Fig. 255.
Mules' Operation. Closure of the Wound.

apparently non-vascular inner surfaces of the sclera together by simple interrupted sutures, a Lembert stitch is used. Three main sutures are first introduced in such a way that when they are tied, 3 mm. of raw episcleral tissue on each side is folded in and brought together, instead of the inner and comparatively non-vascular coat of the sclera. As many sutures as are deemed necessary can then be put right through, and each will be a Lembert suture. The stump, instead of having a projecting point at each end of the line of sutures, is nicely rounded, and owing to the fact that the muscles are placed at a greater mechanical advantage, the motion seemed to me to be better than in the other forms of operation."

[173]Grimsdale and Brewerton. *Text Book of Ophthalmic Operations*, p. 181.
[174]Thomson. Personal communication.

The other erroneous impression which prevails is that sympathetic ophthalmia is likely to occur after a Mules operation. This notion is also incorrect for, although it is not denied that sympathetic ophthalmia may follow this operation, it is frequently difficult to prove *that the operation caused the disease,* since it might have followed some other form of enucleation. Fox[175] has done four hundred and twenty-five Mules operations in fifteen years and has never had a case of sympathetic ophthalmia. I have made many such operations and can reiterate Fox's remarks; and the same may be said of many surgeons. It seems, therefore, to be a reasonably safe procedure and one that should be encouraged and utilized in suitable cases. It should not be forgotten, however, that there is considerable evidence to show that ball implantations do sometimes produce sympathetic ophthalmia.

Gifford[176], in 1908, found that fourteen cases of sympathetic ophthalmia have followed Mules' operations; nine after ordinary

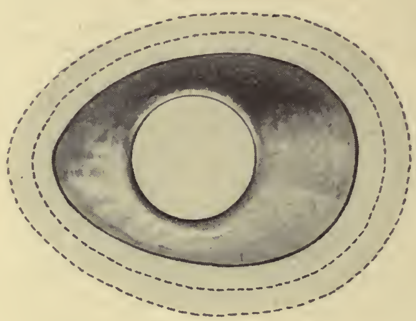

Fig. 256.
Mules' Operation. The Fox Conformer.

evisceration and three after Frost's operation. Gifford acknowledges that in the majority of these cases the same result might have occurred after a simple enucleation, but feels justified in attributing the disease in seven cases to the operation. He thinks the patient should decide whether he wishes to assume the extra risk for the sake of improved cosmetic appearances.

Oliver[177], in 1908, also reports a case of sympathetic ophthalmia which he claims followed a Mules' operation, but the evidence appears to be inconclusive.

Brobst[178], in 1908, reports a case where a Mules operation was

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[175]Fox. *Diseases of the Eye.* 1910.

[176]Gifford. On Sympathetic Ophthalmia After Evisceration and Mules' Operation. *Ophthalmic Record,* November, 1908.

[177]Oliver. *Ophthalmic Record,* November, 1908.

[178]Brobst. Sympathetic Ophthalmia Following Mules' Operation. *Ophthalmic Record,* 1908, p. 583.

performed ten hours after an accident. Sixty days later sympathetic optic neuritis developed and the stump was removed. Recovery followed. The evidence seems quite clear in this case.

Contrary to the opinion of some surgeons, Mules' operation is thoroughly permissible in young people; indeed it is advisable, since it affords the best incentive for development of the orbit, which is, perhaps, arrested after an enucleation or an ordinary evisceration in children. Indeed, de Schweinitz[179] says that this operation "is only contra-indicated by malignant disease, sympathetic ophthalmitis, extensive laceration of the sclera and extreme phthisis bulbi."

Bickerton[180] has prepared a list (modified from Mules) of the advantages the Mules operation possesses over an ordinary enucleation:—

ENUCLEATION	*versus*	MULES' OPERATION.
1. Complete removal of globe and its contents.		1. Retention of the framework of the eye.
2. No stump, therefore a sunken eye.		2. A firm, round globe forming perfect support for artificial eye.
3. Disturbances of all muscular relations and arrest of movement.		3. Perfect harmony of muscular movements retained.
4. A fixing, staring eye attracting attention.		4. Fitted with selected eye defies detection.
5. Patient shuns society.		5. No qualms as to personal appearance.
6. Arrested development of orbit in cases of children.		6. No interference with growth of orbit.

Besides the advantages of the Mules operation already mentioned, it should not be forgotten that when an artificial eye is worn after this procedure the tears flow more readily into the natural channels and dried secretions are not so apt to accumulate on the artificial shell. In all fairness, however, it must be stated that so far as the sixth clause of the above comparative table is concerned, this is a matter of opinion, inasmuch as the committee appointed in 1896 by the Ophthalmological Society of the United Kingdom to consider such matters was unable to find cases of arrested orbital development after removal of an eyeball. Gordon Byers at that time carefully examined in adult life ten cases where the eyeballs had been removed in childhood and he was unable to find any practical difference in the dimensions of the two orbits.

Frost reports a case where a glass globe was inserted, but heal-

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[179] deSchweinitz. Internat. Oph. Congress, 1900. Committee Report.

[180] Bickerton. The Advantages of Mules' Operation. *Am. Journ. Ophthal.*, p. 336.

ing did not occur. An examination disclosed a ball with a small hole. The ball was one-third full of pus. Ayres[181] has reported a similar case.

If a hollow ball is used it should be made either of glass, as proposed by Mules, or of gold, as proposed by Fox.[182] Aluminum, celluloid, sponge, cotton, asbestos, glass, wool, silver, rubber, silk, catgut, peat, wire, agar-agar, bone, vaseline, fat, paraffin, etc., have been proposed, but most of these materials have been condemned after experience in their use had demonstrated their inferiority.

Bryant[183] warmly recommended aluminum balls with fenestrated walls on account of their strength and lightness. He claimed that new tissues formed inside the scleral sac and entered the openings in the ball, thus eventually producing a solid mass of aluminum and living tissue which effectually prevented an expulsion of the ball. Cases reported by Coleman,[184] Fox,[185] Todd[186] and others, however, clearly demonstrated that aluminum balls, when sewed into the scleral sac, are liable to disintegrate and break down, a defect which, of course, entirely destroys their usefulness in this operation. Silver balls, recommended by L. Verrey[187], Bickerton[188] and others, are also objectionable as they produce argyria and are apt to become disintegrated.

The Use of Paraffin in Mules' Operation.

Paraffin as an ocular prothesis was first proposed by Brockaert,[189] in 1901, and since then articles have been written on the subject by Ramsay[190], in 1901 and 1903, Suker[191], in 1903, Oatman[192], in 1902 and 1903, Alter[193] and Hertel[194], in 1903, Lagleyze[195], in 1904, C. N.

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[181]Ayers. Internat. Oph. Congress, 1900. Committee Report.

[182]Fox. Implantation of a Glass Ball for the Better Support of an Artificial Eye. *Diseases of the Eye*, 1910. Also, *N. Y. Med. Journ.*, Jan. 18, 1902

[183]Bryant. Experiments in the Use of Aluminum for Artificial Vitreous. *Journ. Am. Med. Assn.*, Sept. 24, 1898, p. 713.

[184]Coleman. Personal Communication.

[185]Fox. Internat. Oph. Congress, 1900. Committee Report.

[186]Todd. Mules' Operation. *Journ. Am. Med. Assn.*, Nov. 23, 1901, p. 7.

[187]L. Verrey. Cinq cas d'opération de Mules. Evisceration et insertion d'une globe d'argent dans la sclerotique. *Bull. de la Soc. Franç d'Ophtal.*, 1898, p. 164.

[188]T. H. Bickerton. The Operative Treatment, Past and Present, of Injured or Painful Blind Eyes. *Med. Times and Gazette*, May 1, 8, 15, 1897.

[189]Brockaert. Beard's *Ophthalmic Surgery*, p. 416.

[190]A. M. Ramsey. The Cosmetic Value of Paraffin Injections. *Lancet*, Jan. 31, 1903. Also, *Ophthalmic Review*, July, 1903.

[191]G. F. Suker. Grimsdale and Brewerton. *Ophthalmic Operations*, 1907, p. 161.

[192]E. L. Oatman. Plastic Artificial Vitreous. *N. Y. Med. Record*, March 7, 1903.

[193]F. W. Alter. Implantation of a Ball of Solid Paraffin. *Ophthalmic Record*, March, 1903.

[194]E. Hertel. Ueber Paraffinprothese in der Orbit. *Arch. f. Ophthal.*, Vol. 55, 2, p. 239, 1903.

[195]P. Lagleyze. Prothesis Ocular. *Anales de Oftal.*, April, 1904, p. 429.

Spratt[196] and Hitschman,[197] in 1905, and others. Paraffin has certain advantages, viz., it can be cut to any size and shape; the body warmth molds it to the contour of the retaining sclerotic envelope and it is claimed that strands of ocular tissue readily penetrate the mass, thus reducing the chances of extrusion. Hertel,[198] in 1903, found after rabbit experiments that hardened paraffin was the best to use, since soft paraffin was apt to become at least partially absorbed.

Spratt's directions for the preparation of the paraffin and his method of operating are sufficiently explicit to warrant a quotation from his article appearing in the *"Archives of Ophthalmology"* for 1905. It will be observed that his operations have been confined to the implanation of the ball beneath the capsule of Tenon, and not to the Mules operation proper.

"The spheres are prepared as follows: Paraffin with a melting-point of about 60° C., is melted and filtered through ordinary filter-paper into clean test-tubes. These are stopped with cotton and placed in a steam sterilizer. When these have become cool and the paraffin is solid, the glass is heated in hot water or over a flame until the layer of wax next to the glass is liquid. The central solid paraffin rod is readily removed and placed in a warm solution of bichloride. With a knife, this long candle-like piece of wax is divided into suitable-sized pieces and while yet warm is rolled into spheres. During this process, rubber gloves should be worn. The spheres are kept for future use in a wide-mouthed bottle containing a 5% solution of formalin. The most convenient-sized sphere is 17 mm. It is a good plan to have several sizes ranging in diameter from 1.5-2 cm, although the larger sizes can be quickly cut down to a smaller size."

The operation spoken of, by Spratt, is as follows:

"The patient, being under a general anesthetic, the skin about the eye and face is cleaned with soap and water followed by alcohol, ether and bichloride (1: 5000). A double layer of gauze, with an opening over the eye to be operated on, is placed over the face and ether cone. This prevents the sutures and the hands of the operator from coming in contact with the ether inhaler and aids materially in maintaining a clean field of operation. Aseptic precautions should be observed, as an infection is certain to be followed by failure. The conjunctiva is divided close to the limbus and dissected backward beyond the insertion of the recti muscles. These are picked up on a strabismus hook and separated from the surrounding tissue. Before dividing the tendons from their insertion in the sclera, each is caught by a silk suture or held by a small clamp. This prevents retraction of the muscle and the possibility of losing it. The writer uses four Halsted hemostats known as the 'mosquito' pattern. The use of these forceps saves unnecessary puncture of the tendon with the needle and shortens the time of the operation materially. After dividing the tendons close to their insertions, the globe is enucleated in the usual manner. A paraffin globe is then dipped in bichloride to remove the formalin, and cut, if necessary, to the proper size. The globe is seized with a pair of ordinary forceps and placed in Tenon's capsule. An elaborate introducer is entirely unnecessary as the sphere can be placed in position with almost any instrument.

"The superior rectus is sutured to the inferior by a mattress or U-suture and the two lateral recti by a similar suture. A slender full-

[196]C. N. Spratt. The Use of Paraffin Spheres. *Arch. of Ophthal.*, 1905, Vol. 34, No. 2.

[197]R. Hitschman. Hartparaffinkugel-Ausstossung nach einigen Wochen. *Zeitschr. f. Augenheilk.*, Vol. 13, p. 384, 1905.

[198]E. Hertel, *loco cit.*

curve needle threaded with No. 00 chromicized catgut should be used. The large needles tear the tendon unnecessarily and the plain catgut is too rapidly absorbed. To prevent the muscle loops from slipping back over the globe and to give a common point of insertion, an additional suture is placed so as to include each muscle at the crossing of the two loops. Tenon's capsule is closed over the globe by a catgut purse-string suture. This relieves the tension of the muscle sutures, covers the globe with an extra layer of tissue, and prevents the ball from slipping out between the muscles. The conjunctiva is then closed with a purse-string, making, in all, three layers.

"Care must be taken during the operation not to puncture the tendons unnecessarily, as each needle puncture causes the fibres to separate and a possible cutting through of the sutures. Too large a sphere should not be used, as this places tension on the sutures. In the adult a globe 17 mm. in diameter will be found the most suitable size. After the enucleation the hemorrhage may be rather free, but the insertion of the paraffin checks this. No irrigation is used during the operation. A firm gauze dressing is placed over the eye. This is changed daily for the next four or five days and then discontinued. The pressure bandage has been found to lessen the subsequent chemosis. The reaction following the operation is about the same as after an evisceration. Chemosis, as a rule, lasts less than a week, but may, in exceptional cases, continue longer. One patient was discharged from the hospital with no chemosis on the fifth day. Two cases had thickened conjunctivæ thirty and thirty-five days. The writer has, however, seen chemosis and ecchymosis eight weeks after a simple enucleation.

"The writer believes that the insertion of a paraffin sphere in Tenon's capsule is the operation of choice in all cases requiring the removal of an eye, except when a malignant growth involves the orbital tissue or panophthalmitis is present. In the former cases, exenteration of the orbit; in the latter condition, evisceration with good free drainage of the scleral cavity, are the operations preferred.

"*Conclusions*: The modified Mules or Frost operation combines the cosmetic results of Mules with the advantages of simple enucleation. These are:

"1. Good cosmetic result is obtained; the artificial eye has good motion; the eye does not have a receding appearance; and the glass is in contact with the lids.

"2. Secretions will not accumulate in the hollow behind the eye, as this is occupied by the stump.

"3. Globe is preserved in toto for microscopic or macroscopic preparations.

"4. No danger of overlooking malignant intraocular tumors.

"5. Best prophylaxis against sympathetic ophthalmia. Paraffin is the most suitable material for the prothesis.

1. It is non-irritating and least likely to be extruded.
2. Spheres can be easily made and are inexpensive.
3. No danger of being broken.
4. Paraffin adapts itself to the shape of the cavity, is soon surrounded by a fibrous capsule, and is firmly held in place by connective-tissue down growths."

Ramsay[199] prefers to use melted paraffin instead of the gold balls. The essential steps of his operation are as follows. After the conjunctiva has been cut and separated from the eyeball, each muscle is caught up by a hook, a catgut thread passed through it and its overlying conjunctiva, and the tendons severed. The eye is then removed. The four recti muscles which have been tenotomized are now put upon a stretch and the cavity left by the removed eye is tamponed with

[199] A. M. Ramsay, *loco cit.*

adrenalized gauze which will soon control the hemorrhage, after which a strong, black silk purse-string suture is passed through the muscles, conjunctiva, etc. The socket is now dried and filled with melted sterilized paraffin, at a temperature of 104°F. This is accomplished by using a metal, rubber-jacketed syringe, the nozzle of which is inserted into the capsule of Tenon and the liquid paraffin injected. The catgut sutures should then tie the muscles together in opposite pairs and the black silk, purse-string suture should also be tightened and tied, and the operation then completed.

Ramsay claims that the paraffin molds itself to the socket and that the tissues become attached to the ball. Some reaction follows the operation and the silk suture is removed in about two weeks. He also says that in thirty-four cases the globe escaped three times.

Oatman[200], who uses a hard paraffin ball, in 1903 drew attention to a feature of paraffin globes which is certainly worthy of consideration. He says that in using unyielding substances, such as glass

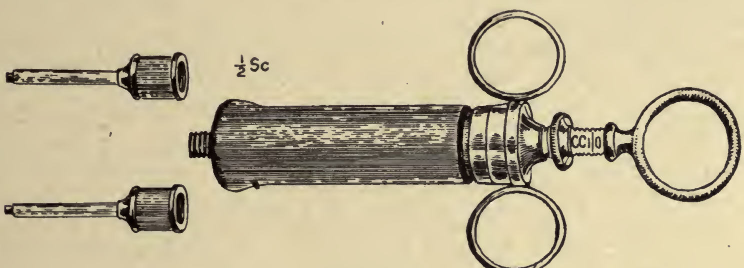

Fig. 257.
Ramsay's Paraffin Syringe.

or gold, when once the incision opens and the globe can be seen, the result is inevitable; the globe sooner or later escapes if it is not instantly removed by the surgeon, which, after all, is the best plan. With paraffin globes, however, if the incision opens, there is still an excellent chance for its retention because portions of the balls can be scraped away by using a small, sharp, heated spoon, after which the wound margins can be freshened and resutured, or, even if the sutures are not applied, the wound frequently closes spontaneously, if enough paraffin has been removed, an event which will be favored by the natural softening and escape of considerable paraffin through the fistulous opening.

Objections have been raised by Davis, Parker and others that paraffin spheres are apt to produce sympathetic irritation, but such fears have not been substantiated by a sufficient number of cases to warrant this conclusion. In using melted paraffin, however, the re-

[200]E. L. Oatman, *loco cit.*

mote possibility (as pointed out by Hertel[201], Hurd[202], Holden[203] and others) of producing embolism should not be entirely forgotten, although when the paraffin is not introduced into the open socket until after the ends of the vessels are plugged, as indicated by a cessation of hemorrhage, there is certainly but little likelihood of any paraffin entering a blood vessel.

Other Substitutes for the Glass Ball in Mules' Operation.

Sponge. Claiborne[204], in 1889, and Belt[205], in 1896, advocated the insertion of a well-sterilized piece of soft sponge beneath the capsule of Tenon, muscles and conjunctiva. Belt said that "in a few weeks the sponge is filled with new tissue, which in time becomes firm, solid flesh, making a full orbit and a fine support for the artificial eye." The sponge fibres are apparently absorbed.

Claiborne at the same time experimented unsuccessfully with *masses of cotton* inserted into the scleral cavity. In 1896 Claiborne[206] also reported some unsatisfactory experiments in placing balls of sponge, cotton, asbestos, glass and wool within the scleral walls. He concludes that these materials are unsuitable for the purpose. Bourgeois[207] recommended a ball of silk, which he used in the same way as Belt's sponge.

The method of Belt was tried and recommended by Trousseau[208] in 1897, Risley[209] in 1898, Suker[210] in 1900, Chandler[211] and others, but the operation has never been much used and later was discarded by Belt[212] himself and practically all the other experimenters.

In 1900 Suker[213] proposed the following procedure which seems to be a combination of several operations:

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[201]E. Hertel, *loco cit.*

[202]L. M. Hurd. A Case of Paraffin Injection. *N. Y. Med. Record*, July 11, 1903.

[203]W. A. Holden. A Case of Paraffin Injection. *N. Y. Med. Record*, July 11, 1903.

[204]J. H. Claiborne, Jr. On the Formation of an Artificial Vitreous Body, with a View to Making a Good Stump for the Accurate Fitting of Glass Eyes. *Gaillard's Med. Journal*, May, 1889, p. 431.

[205]E. O. Belt. Sponge Grafting in the Orbit. *Ophthalmic Record*, September, 1896. Also, *Med. News*, June 27, 1896.

[206]J. H. Claiborne, Jr. Some Experiments on Rabbits, Made with a View to Obtaining a Stump for the Accurate Fitting of Glass Eyes. *Journ. Am. Med. Assn.*, Nov. 21, 1896, p. 1091.

[207]A. Bourgeois. Critique de l'operation de Mules; Intervention destinée à être substituée. *La Clinique Ophtal.*, May 25, 1898, Vol. 4.

[208]A. Trousseau. La Greffe d'éponge comme reinforcement du moignon après l'énucleation. *Annales d'Oculist.*, Dec., 1897, p. 417. Also, *La Presse Med.*, Jan. 22, 1898, p. 45.

[209]S. D. Risley. The Late Results in a Case of Implantation of Sponge. *University Med. Magazine*, May, 1899. Also, Implantation of Sponge Into the Orbit, *University Med. Magazine*, September, 1898.

[210]Suker. Internat. Oph. Congress, 1900. Committee Report.

[211]Chandler. Internat. Oph. Congress, 1900. Committee Report.

[212]Belt. Internat. Oph. Congress, 1900. Committee Report.

[213]Suker. Internat. Oph. Congress, 1900. Committee Report.

"The eyeball is removed by the ordinary method, care being taken to save as much of the conjunctiva as possible. The recti muscles are severed as close to the eyeball as possible, and each provisionally anchored by a black silk suture. The cavity, after the eyeball has been removed, is completely evacuated, and all hemorrhage checked before the artificial combination globe is inserted. Avoid using even the weakest solution of bichlorid of mercury during the operation, but instead use a sterilized normal salt solution. This for the reason that the former agent is prone to attack the vitality of the tissues and cause more or less annoyance.

"A suitable and sufficiently large artificial globe (of glass, silver, aluminum, etc.), properly sterilized, is embedded or wrapped up in a layer of very fine surgeon's sponge, likewise aseptic, and tied or sewed with catgut. This embedded globe is inserted into the capsule cavity. The capsule is next sutured with catgut (chromicized). The recti muscles are now brought together in pairs, and the whole fixed by an annular ligament. The black silk sutures are now removed from the recti muscles. Next, the conjunctiva is brought over the muscles, and sutured with silk or catgut. It is best to employ two sets of sutures for the conjunctiva: a so-called edge suture and an anchor suture alternating. This anchor or retention suture is placed as far back as possible from the cut edge of the conjunctiva, in order to relieve any strain upon the continuous or interrupted edge sutures.

"The eye is now dressed with a dry dressing—gauze pad immersed in one part boric acid and four parts amyloform— and if everything has been thoroughly aseptic during the operation, very little reaction or consequent suppuration supervenes. Above all things avoid using pressure bandages. It is advisable to employ an ice bag for the first twenty-four or thirty-six hours. Great caution must be observed in preparing the sponge and globe so as to have each thoroughly aseptic—especially is this true of the sponge."

The *implantation of fat taken from the gluteal region* and inserted into the capsule of Tenon after an enucleation had been performed, was recommended in 1901 and 1903 by Barraquer[214]. The fatty mass was held in position by suturing over it the muscles, capsule and conjunctiva. He reported some excellent results. D. Velez[215], F. Lopez[216] and U. Troncoso[217], in 1903, performed similar operations with success and have also implanted fat within the scleral sac.

In 1904 Rollet[218] inserted into the capsule of Tenon a lump of fat and skin taken from the deltoid region. The segment of skin should be a little larger than the cornea. The mass of tissue is placed in the capsule with the skin side out. The four recti muscles are sutured to the mass and then the conjunctiva is stitched to the skin all around its periphery. Rollet claims good results and a mobile stump.

In 1908 Bartels[219] discussed the method in a paper before the Ophthalmological Congress at Heidelberg. He made some experiments

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[214]Barraquer. Enucleacion ingerto de tejido adepaso en la capsule de Tenón. *Archiv. de Oftal. Hisp.-Amer.*, Vol. 1, 1901, p. 82.

[215]Velez. Comparativo de las diversas operaciones propestas pora remplagar à la enucleacion y especialmente de las implantaciones de grasa. *Arch. de Oftal. Hisp.-Amer.*, July, 1903, p. 506.

[216]Lapez. *Idem.*

[217]Troncoso. Ueber Enucleation mit Fett-Implantation. *Bericht der Ophthal. Gesell. in Wien*, March 9, 1910.

[218]Rollet. *Ophthalmic Operations.* Grimsdale and Brewerton, p. 186.

[219]Bartels. Verpflanzung von Fett in die Tenonsche Kapsel. *Bericht der Ophthalm. Gesell.* Heidelburg, 1908, p. 333.

on dogs and operations on human beings. He suggested also the use of fat implantation into the scleral sac, as well as into the walls of the capsule of Tenon. In 1908 Valez[220] reported ten successful cases of fat implantation and warmly recommended the procedure in 1910. Alling[221] reported two successful cases, and in the same year Ibershoff[222] also indorsed the operation and claimed good results. There was but little decrease in the size of the stump, after one year had elapsed.

In 1910 Hans Lauber[223] reported to the Ophthalmological Society of Vienna 37 cases of fat implantation into the capsule of Tenon. His cases were almost all successful, and while some shrinkage of the stumps ultimately took place, he secured prominent, movable stumps in most instances, that afforded excellent and mobile support for an artificial eye. He enucleates the eye in the usual manner, but secures each muscle with a quilted catgut suture before allowing it to retract into the socket. After the eyeball is removed the lump of fat is placed within the capsule of Tenon and the capsule and muscles drawn over it with catgut. The conjunctiva is then stitched over the entire mass with silk sutures which are removed in from 8 to 10 days, unless they have meantime been spontaneously expelled. The fat should be gently cut with scissors and as a single mass from its normal location. It ought to be large enough to fill the capsule and yet not so large as to induce tension upon the enveloping walls or the sutures. Any extruding fat should be excised. Sometimes considerable pain, with edema of the lids and conjunctiva, occurs which, however, soon disappears.

Landmann[224], in 1902, recommended wire balls instead of hollow spheres in Mules' operation. He claims as peculiar advantages that they are light and that they become solidly anchored in the socket by granulation tissue springing up between the wires which binds the ball down permanently and prevents its extrusion. The ball is made "of seven vertical, complete circles of silver wire and three horizontal circles, soldered at their intersections." This method has never been much used, but if used, gold wire would surely be preferable to silver.

Pick[225], in 1898, recommended hollow rubber balls and tried the

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[220]Velez. Ueber Enucleation mit Fett-Implantation. Article by H. Lauber, *Bericht der Ophthal. Gesell. in Wien*, March 9, 1910.

[221]Alling. Transplantation of fat into Tenon's Capsule. *Ophthalmic Record*, March, 1910, p. 127.

[222]Ibershoff. The Use of a Mass of Fatty Tissue as a Stump. *Ophthalmic Record*, March, 1910, p. 142.

[223]Lauber. *loco cit.*

[224]Landmann. Implantation of Wire Balls. *Am. Journ. of Ophthal.*, May, 1902.

[225]Pick. An Experiment on a Rabbit's Eye. *Journ. Am. Med. Assoc.*, Jan. 8, 1898, p. 66.

experiment upon one rabbit. The animal unfortunately accidentally died and no more efforts were made.

Silver balls have never been much used as they cause a dark stain on the surrounding tissues and undergo oxidation.

Agar-agar, tried by Suker[226] and Gifford[227], was finally condemned by both as not producing a sufficiently prominent stump.

In 1906 H. Schmidt[228] proposed the implantation of balls of polished bone, and reported some favorable results.

Balls of elder-pitch have been recently (1909) employed by Elschnig[229] and Waldstein[230], who are much pleased with the results.

So far as the surface *roughening of the glass globe* is concerned, if it occurs, it is difficult to conceive how this can do any damage under the circumstances. Nevertheless there is no apparent objection to the use of gold balls if one desires.

Certainly, of all balls or substances that have as yet been proposed for any form of implantation operation, those of glass or gold are declared generally to be the best.

Suker[231], in 1907, lays much emphasis on the superiority of "lead-free glass," for he says that our bodies "furnish no acids or alkalies that affect lead-free glass."

So far as the breaking of glass globes is concerned, I have yet to see the record of one case where this has occurred. They are very strong.

Lauber[232], in 1910, says that "if the reason is sought for the unfortunate results following the various implantation operations, it can be found in the nature of the implanted body itself. Such transplanted structures are expelled either from chemical reaction, with resultant inflammation, as mentioned by Zeitz[233] and Hertel[234], or in the production of traction upon the scleral and other surrounding tissues. The smaller the chemical activity of the implanted body, the better will it endure the test." This is one of the principal reasons why Lauber recommends balls of fat. It is the patient's own tissues that are being transplanted, and Lauber feels (with the writer) that there

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[226]Suker. On the Employment of Agar-Agar in the Formation of a Stump After Enucleation or Evisceration. *Ophthalmic Record*, Vol. 10, No. 9, p. 466.

[227]Gifford. *Idem.*

[228]Schmidt. Zur Lösung des Problems der Kugeleinheilung. *Zeitschr. f. Augenheilk.*, Vol. 16, Erg. Heft, 1906, p. 63.

[229]Elschnig. Article by E. Waldstein—Frage der Kugeleinheilung bei Enucleation und Exenteratio bulbi. *Klin. Monatsbl. f. Augenheilk.*, 1907, p. 118.

[230]Waldstein. *Idem.*

[231]Suker. Can a Substitute for Simple Enucleation be Employed? *Annals of Ophthal.*, 1907, p. 208.

[232]Lauber, *loco cit.*

[233]Zeitz. *Idem.*

[234]Hertel. *Idem.*

is less liability of chemical antagonism from this source. The reasoning is plausible and the results ought to be good.

The Frost-Lang and Morton-Oliver Operations.

These operations have so many points in common that they will be considered together.

The Ferrall-Bonnet operation, or the modification which I generally use and have already described, can be supplemented by the insertion of a ball into the tissues. This procedure sets up much less reaction than when the ball is inserted into the scleral sac, as in the regular Mules' operation, and makes a fine, movable stump. The method was devised by Adams Frost, in 1886. After the Bonnet operation, a ball may be dropped into the cavity previously occupied by the globe, after which a strong, silk suture should unite the superior and inferior recti muscles, the same stitch including the overlying conjunctiva. Another suture should unite the internal and external recti muscles and conjunctiva.

The inclusion of the capsule of Tenon in the sutures was the idea of Lang[235], who proposed this procedure shortly after the Frost[236] operation was suggested. The subsequent treatment is the same as after a Mules' operation. Great care should be taken to see that the ball is placed and remains in the center of the socket, as it is very easy for it to slip to one side or the other.

In 1897 Morton[237] described an operation similar to the Lang operation, the details of which are here quoted:

"The patient being anesthetized, a circular incision is made in the conjunctiva close to the corneal limbus. The internal rectus is dissected free from surrounding tissues up to its attachment to the globe, and held by a pair of advancement forceps, after which it is cut close to the sclera. A double needle catgut suture is passed from within outward, inclosing the central bundle of the tendon and tied to its external surface. The ends of the suture, which are cut to a generous length, are now laid aside to the nasal side of the field of operation. The external, the superior and inferior recti are treated in a similar manner. The oblique muscles are cut, and, no suture being used, escape. The globe is removed after section of the nerve, and all capillary hemorrhage stopped before we proceed. The glass sphere is now placed into the cavity previously occupied by the eyeball, and now lined with the parietal and a portion of the visceral layer of Tenon's capsule.

The sutures holding the externus and the internus are now taken by the operator, the assistant taking at the same time the sutures retaining the superior and inferior recti. Before the second turn is made in the sutures held by the operator, the assistant ties the sutures together, and these are inclosed in the final turn of the knot holding the external and internal recti. The sutures are now inclosed in a common knot at their intersection.

I have attempted to explain this process of tying the sutures in detail,

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[235]Lang. *Trans. Ophthal. Soc. U. K.*, Vol. 7, 1887, p. 242.

[236]Frost. *British Med. Assn.*, 1886. Also, *British Med. Journ.*, 1887, 1, p. 1153.

[237]Morton. The Insertion of an Artificial Globe into Tenon's Capsule. *N. Y. Med. Journ.*, Oct. 30, 1897.

since it is of the most vital importance for two good reasons, as I will now proceed to explain. In the first place, should the sutures slip over the glass sphere (the horizontal up or down, the vertical in or out), it would escape from the cavity as placed, and put all of the strain upon the light silk sutures in the conjunctival wound. The second is, if anything, a more important reason; for, should the suture slip, the normal position of the muscles (as retained by this method) upon the glass ball is disturbed, and a condition of unequal tension results, which destroys the proper movement of the artificial bulb. This is a point in the operation that I desire to lay stress upon—i. e., the careful adaptation of the sutures, so that the tendons assume the same position they occupied in the living eye. By attention to this point, which is obtained by the method of tying the sutures, the excursions of the artificial ball are as unrestricted as in the Mules' operation. The muscles are retained in their place by a process of adhesive inflammation to the over-lying and surrounding conjunctiva, which is completed before the sutures are absorbed. It must be clearly understood that the tendons are not sutured together, but merely held in a normal position until retained by the inflammatory process. The catgut sutures and sphere are now covered by the conjunctiva, which is held by interrupted sutures of Chinese silk. I dust some finely powdered iodoform into the cul-de-sac and apply a bandage, which is allowed to remain for three days. It is interesting to note that the reaction which follows in this operation is very slight, and as a rule causes the patient no pain or elevation of temperature. At the end of three weeks the patients wear the artificial eye with comfort."

The reaction after operations of this nature is practically no greater than after an enucleation, and the stay in the hospital is about the same. The tendency to escape or displacement of the ball can usually be overcome by care in applying the muscular and scleral sutures. Nevertheless it must not be forgotten that the globe does sometimes escape and there is sometimes considerable reaction and cellulitis. Suker records a case of sympathetic irritation, where the removal of the ball relieved this condition. These operations often give nearly as good cosmetic results as a Mules' operation.

In 1898 J. W. Barrett[238] advised the following method of applying the sutures after introducing a glass globe into Tenon's capsule:

"The operation of enucleation is proceeded with in the usual way. Then the needle is passed in through the conjunctiva about ten mm. from the cut edge, in the position of the tendon of the inferior rectus. It is then passed from within outwards in the position of the external rectus, at the same distance from the cut edge, back from without inwards in almost the same position; it is then passed from within outwards and back again, in the position of the superior rectus and of the external rectus, and finally from within outwards, in the position of the inferior rectus, so the two ends of the suture are close together. The globe is inserted and the suture is tightly tied. The conjunctiva, capsule of Tenon and tendinous expansion of the muscles are therefore drawn firmly in front of the globe and about 10 mm. of conjunctiva and capsule are loose in front of the suture. The edges of the conjunctiva are now joined by a fine suture."

After the modification of Bonnet's operation which I employ, and which I have already described, a ball may be dropped into the socket and the purse-string suture including muscles and conjunctiva closed over it, but it is better in this procedure to use a strong silk

[238]Barrett. *Intercolonial Med. Journ. of Australia*, 1898, III, p. 210.

instead of a catgut suture. The after-treatment of a Mules' operation should be employed.

Wm. W. Sweet [Implantation of a Metal Ball in Tenon's Capsule (The Frost-Lang Operation), *Archives of Ophthal.*, Sept., 1910, p. 467] reports the results of forty-eight cases in which a ball was inserted in Tenon's capsule. He performed forty-eight operations in this period of time with the loss of two balls. He used gold balls in forty-two cases, and platinum balls in six cases. In five of the cases there was evidence of sympathetic irritation at the time of the operation which subsided after the surgical procedure. In the two cases where the ball was lost an excellent movable stump was obtained. He thinks the operation is entirely safe in all cases where malignant growths or purulency are not present. He does not advocate, however, the operation in case of shrunken eye balls. He does not believe there is anl greater danger of sympathetic ophthalmia than when an

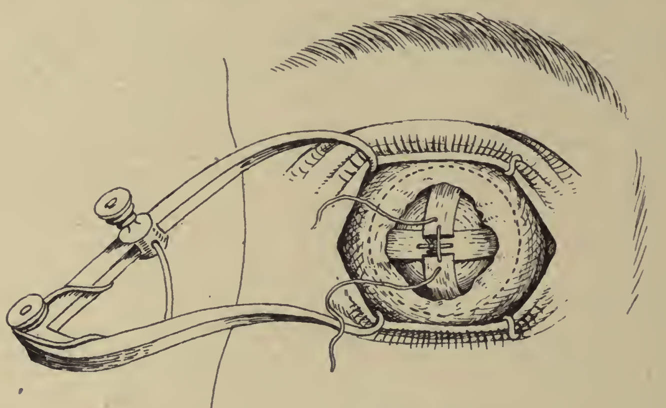

Fig. 258.
Implantation of Ball (Oliver). The Four Sutured Recti Muscles.

ordinary enucleation is performed. He thinks that gold balls are lighter than platinum balls and are, therefore, to be preferred. His method of operating is as follows:

After the conjunctiva has been dissected loose at the limbus, and the usual precautions to preserve all the structures have been observed, the four straight muscles are picked up on a trabismus hook and stitched to the conjunctiva in the normal position or brought forward to the edges of the cut conjunctiva. After the nerve has been cut and the eyeball removed, hemorrhage is stopped by pressure of dry sterile gauze pads, the upper and lower borders of Tenon's capsule are picked up with forceps and the ball placed in the exposed cavity. A stitch is inserted through the upper and lower edges of the centre of the capsule and tied; one end of the thread is cut off, while the other is used to raise the capsule that the sutures may be more readily inserted. From 6 to 8 will usually be required to join the edges of the capsule. Should any portion of the capsule be so thin that the ball shows through, a tuck of the adjoining tissues should be made and the thinned portion covered. The conjunctival edges are now brought together by interrupted sutures placed horizontally. A binocular bandage is applied, but no

iced compresses are employed. At the dressing the following day the monocular bandage is used, and the patient allowed to get up. Should edema of the lids be present, cold formalin applications may be made through the light bandage.

Oliver[239], in 1899, proposed the following procedure for which he claims excellent results:

"The conjunctiva around the entire corneal limbus is freed from the globe and dissected sufficiently far back so as to expose the tendons of the four recti muscles. The tendinous extremities of the muscles are made ready for separation from the globe. A half-curved needle with its point directed toward the corneal border, and holding a long piece of catgut thread, is carried directly through the belly of the internal or the external rectus muscle, and brought out of the tendon of the muscle just behind the remaining attachment to the globe. The muscle thus secured is cut loose from the globe just as in an ordinary tenotomy. The catgut thread is drawn through as far as practicable, and a sufficient length of the strand of gut is left untouched in order to allow a loop broad enough for free manipulation between it and the eyeball. The needle is carried over to the opposite side of the cornea, and, with its point directed away from the

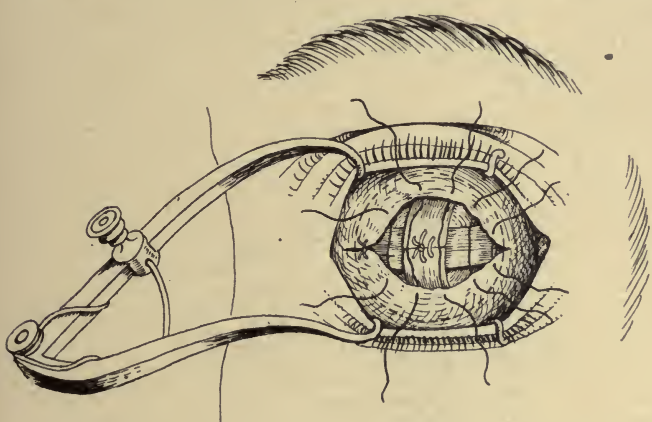

Fig. 259.
Implantation of Ball (Oliver). Suturing the Conjunctival Opening.

cornea, is made to transfix the tendinous belly of the lateral muscle, which is secured and freed from its connection with the eyeball.

The vertically-placed muscles are dealt with in a similar manner.

The four recti muscles are thus freed from their tendinous attachments to the globe, and each pair of muscles is secured in a loose sling that can be tied the moment that this becomes necessary.

Working in between the broad loops of catgut attached to the ends of the muscles that are held apart by an assistant the eyeball is enucleated with as much of the optic nerve as may be desired, without any difficulty.

The cavity previously occupied by the globe is thoroughly cleansed and a water-tight glass ball of about three-fourths of the size of the normal globe is dropped into place.

The ends of the lateral recti muscles which are held by the lower and the first placed catgut thread are neatly trimmed and sutured together. The same is done with the two ends of the vertical recti muscles. The circular opening made by the cut edges of the overlying conjunctiva is length-

[239]Oliver. Description of a New Method for the Implantation of Glass Eyes into the Orbital Cavity. *Phil. Med. Journ.*, May 27, 1899, p. 1182.

ened into a lozenge by a couple of horizontal snips, and is carefully brought into linear apposition by a series of silk threads.

The operative field is covered by a gauze protective bandage upon which iced compresses are placed.

If the operation be done under strict asepsis, without any undue violence, and the parts be kept thoroughly freed from blood-clots and loose or hanging tissue, and if iced compresses be employed for the first 24 to 48 hours after the procedure, there will be absolutely no reaction, and the surfaces will be ready for the insertion of an artificial eye in a very brief time—in fact, earlier than after an ordinary enucleation, while the cosmetic results will be fully as good as those that are gotten by Mules' method.

The operation is offered on trial for cases in which abscission, keratectomy, or evisceration with insertion of artificial vitreous are inadvisable or impossible, such as in many cases of phthisis bulbi, extensive ruptures of the sclera, etc., thus giving opportunity to obtain well-fitting and freely mobile artificial eyes in cases in which it is necessary that a globe without any of the other orbital contents must be sacrificed."

The Operation for Delayed Implantation.

The implantation of a ball into the orbital tissues some time after a Ferrall-Bonnet enucleation, as suggested by Fox[240], in 1895, is a de-

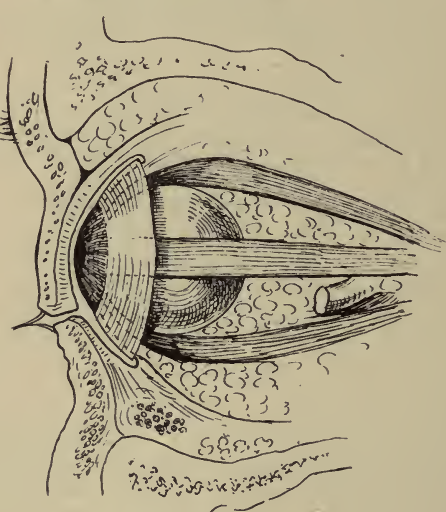

Fig. 260.

Implantation of Ball (Oliver). The Ball and the Artificial Shell in Position.

sirable surgical procedure, as it transforms a deep, sunken cavity into a prominent stump and is one that gives a life-like appearance to an artificial eye. The operation is performed as follows:—

The conjunctiva of the socket is firmly grasped by forceps and an incision is made about three-quarters of an inch long through it and somewhat into the underlying tissues. The incision should lie

[240]Fox. *Diseases of the Eye*. 1910. Also, Implantation of a Glass Ball, *Journ. Am. Med. Assoc.*. Jan. 8, 1898, p. 65. Also, *Trans. Sec. Ophthal.*, Am. Med. Assoc., 1898, p. 80.

either between the location of the superior and internal recti, or between the superior and external recti muscles, and should be at about an angle of 45°. A thorough separation of the tissues should be made with knives and scissors so that a space is produced (in the center of the socket) large enough to accommodate a ball, and deep enough to secure its retention. It will be observed that when the ball is in its central position there are no stitches directly over it, they are off to one side, which, of course, greatly adds to the security with which the ball retains its position. After the space has been made for the ball, it is inserted into its place and the incision securely sutured by an abundance of silk sutures inserted well back into the tissues to guard against their untimely liberation. The conformer is used and the after-treatment is the same as for a Mules' operation. The sutures may be removed in six or seven days. Sometimes Fox dispenses with

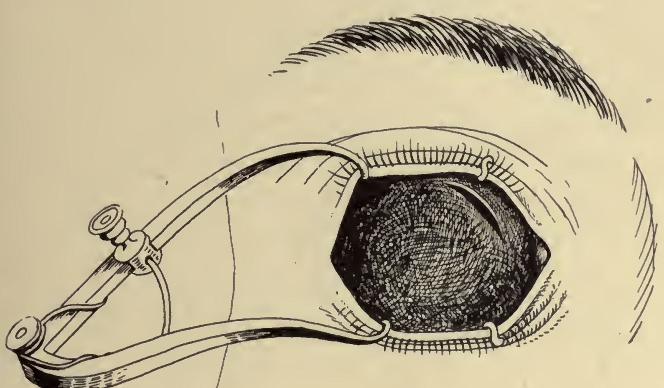

Fig. 261.
Delayed Implantation (Fox). The Opening in the Socket.

sutures. There is not much motion to the ball, owing to the contraction and disuse of the recti muscles, the stump is prominent, well supports an artificial shell and undoubtedly relieves the deformity.

L. Borsch, of Paris, describes an operation for the same purpose. The paper is entitled *Operation pour permettre l'adoption de la Prothèse aprés Ènucleation,* which he presented before the French Ophthalmological Society in 1898. A hollow, half-spherical shell is introduced into the apex of the socket, after the superficial tissues have been undermined by a spatula-shaped knife. A vertical incision is made at the apex of the socket, and the tissues undermined to the right and to the left sufficiently to admit easily the hollow shell, which is then confined in its position by firmly suturing the vertical incision. In proper time the artificial eye is placed over the prominent stump. Borsch prefers gold or

silver shells. It should not be forgotten in this connection that silver shells discolor the tissues, and that lead-free glass shells do not become rough or irritating.

Suker (*Annals of Ophthalmology,* January, 1903) advocated a similar operation, but used paraffin instead of a glass or gold ball. He makes a pocket in the apex of the socket and passes a suture through the lips of the wound. He then injects paraffin into the pocket and ties the suture.

OPTICO-CILIARY NEUROTOMY OR NEURECTOMY.

Optico-ciliary neurotomy or neurectomy is seldom a substitute for enucleation, but if employed as such, is especially applicable in painful, sightless eyes of normal appearance and unaffected by tumors. The operation is particularly useful in cases of *absolute glaucoma,* for, ac-

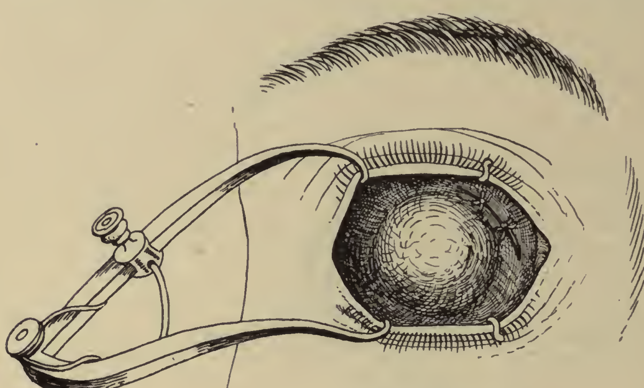

Fig. 262.

Delayed Implantation (Fox). The Ball in Position and the Opening Sutured.

cording to Nicati,[241] whose experiments are mentioned by Fage,[242] section of the ciliary nerves moderates or lessens the secretion of the aqueous humor, while section of the optic nerve favors filtration by widely opening the sheaths of the nerve.

When first systematically proposed and practised by Schoeler,[243] in 1879, it was thought by many surgeons to be applicable mostly in cases where foreign bodies were lodged within the eyeball, and could not be safely removed. It was thought that this operation would give

[241] Nicati. Optico-Ciliary Resection. Trans. from *Archiv. d'Ophtal.*, Dec., 1900.

[242] Fage. Résection Optico-Ciliaire dans des cas de Glaucoma absolutum, *Arch. d'ophtal.*, Dec., 1900, p. 647.

[243] Schoeler. A New Instrument for Performing Optic-Ciliary Neurotomy. *Archiv. of Ophthal.*, Vol. 16, 1887, p. 37. Also, article by C. Schweigger, On Resection of the Optic Nerve. *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3.

the patient a chance to retain the eyeball and that sympathetic ophthalmia would be prevented by severing the optic and ciliary nerves. When the magnet was introduced, however, it was found possible to remove many foreign bodies and the opinion of surgeons soon became crystallized into the belief that it was unsafe to allow an eyeball to remain that permanently harbors a foreign body, unless, perhaps, such an invader be lodged in the lens; and even this exception has by no means been received as good surgery by a majority of ophthalmologists. If, however, it is deemed expedient to allow a foreign body to remain in the eyeball without enucleation, or some substitute therefor, the operation of optico-ciliary neurotomy should certainly be performed.

Although Schoeler was the first surgeon to adopt this procedure and put it to considerable use, it must not be supposed that he was the

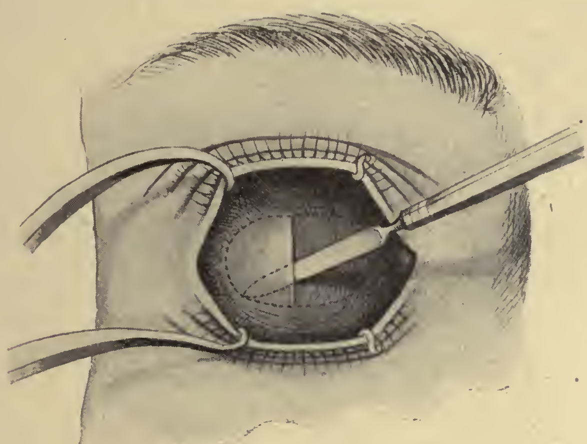

Fig. 263.

Delayed Implantation (Lagrange). The Opening in the Socket and the Tissues Being Undermined.

first to propose the operation, for as early as 1853, Arlt,[244] who believed in the theory of sympathetic ophthalmia by way of the ciliary nerves, suggested their division, a view which was also shared by H. Müller.[245]

In 1857, von Graefe,[246] who believed that the disease was carried by the optic nerve, suggested its division as a preventative measure. The idea of severing both the ciliary nerves and optic nerves, to cover the possibilities of both theories, was a natural evolution, and in 1866 Rondeau formally proposed this procedure after experimenting on

[244]Arlt. On Resection of the Optic Nerve, *Arch. Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 223.

[245]Mueller. *Idem.*

[246]v. Graefe. *Idem.*

many cadavers. The operation then became known as "optico-ciliary neurotomy."

Rondeau[247] operated without cutting any muscles by incising the upper and inner portion of the conjunctiva. He then cut the nerves by passing behind the eyeball with a narrow, curved tenotome.

The operation fell more or less into disuse, but was finally revived by Boucheron[248] in 1876, who operated without myotomy or tenotomy, but opened the conjunctiva between the superior and external recti muscles and pulled the posterior portion of the eyeball forward with sharp forceps, to facilitate the cutting of the optic and ciliary nerves. Later, he advocated severing the internal rectus muscle and holding it aside by a suture to provide ample field for the op-

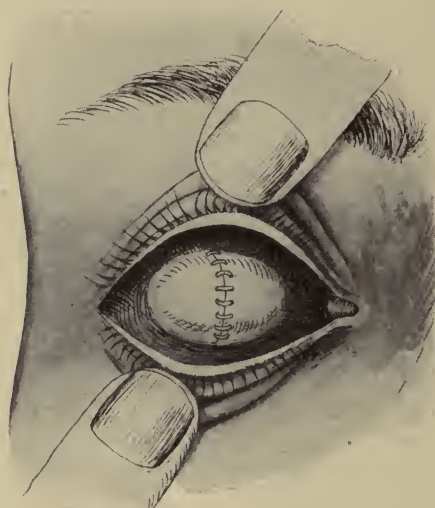

Fig. 264.

Delayed Implantation (Lagrange). The Hollow Shell in Position and the Tissues Sutured over it.

eration and observation. After the optic and ciliary nerves were severed and the hemorrhage had ceased, a firm compress bandage was applied.

As has been said, Schoeler in 1878, began to do the operation frequently. He opened the conjunctival sac more extensively, tied and cut off the external rectus muscle and thus gained a larger operative field. The muscle was subsequently reattached to the eyeball by sutures.

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[247]Rondeau. *Idem.*
[248]Boucheron. *Idem.*

In 1878 Schweigger[249] performed many such operations, but altered the technic by operating from the nasal side, as recommended by Meyer[250] and others, and by exsecting a piece of the optic nerve at least 10 mm. long. He claimed that the nerve was more easily reached from the nasal side, that the oblique muscles were in the way and must be severed when operating from the temporal side. By exsecting a portion of the nerve the two ends would not unite and that infection could not, consequently, pass through it into the fellow eye.

Schweigger laid great stress on removing a *large* section of the optic nerve as he believed that sympathetic ophthalmia is the result of infection from the opposite eye and that the ciliary nerves have little or nothing to do with it. Meyer went a step farther and advised the division not only of the internal and external recti muscles, but the ob-

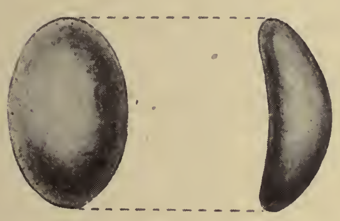

Fig. 265.
Delayed Implantation (Lagrange). The Hollow Shells.

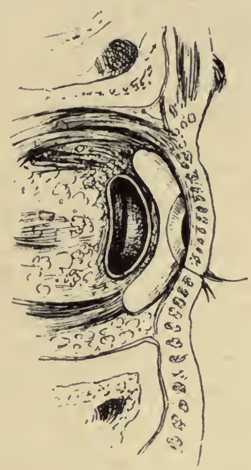

Fig. 266.
Delayed Implantation (Lagrange). Showing the Completed Operation and the Artificial Eye in Position.

lique as well, so that the eyeball might be rotated with perfect ease and the nerve fully exposed to view. Schweigger also recommended that the posterior pole of the eye be pulled forward not by forceps but by a hook caught in the sclera. His hook had only a single arm. Schweigger severed the internal rectus muscle, but before doing so he sutured

[249]Schweigger. Hugo Wolff. An Operation which Increases the Motility of Artificial Eyes and their Partial Replacement by a New Prothesis of a Peculiar Form. *Arch. of Ophthal.*, July, 1899. Also, article by C. Schweigger, Resection of the Optic Nerve, *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 223.

[250]E. Meyer. Briggs. A New Instrument for Performing Optico-Ciliary Neurotomy. *Arch. of Ophthal.*, Vol. 16, No. 1, 1886, p. 37. Also, article by C. Schweigger, On Resection of the Optic Nerve, *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 223.

the tendon and conjunctiva together with two catgut strands, one near the insertion of the muscle and the other a little farther back. He then severed the muscle, conjunctiva, etc., between the two sutures. An assistant utilized these sutures (which were left long) to pull aside the conjunctiva and freely expose the eyeball. He then generally cut through the insertion of the oblique muscles. After severing the nerve, etc., the wound was closed by tying the two sutures. He sutured the upper and lower lids together and applied a compress bandage, to prevent protrusion of the eyeball. He called attention to the fact that severe ecchymosis often occurs and this frequently extends to the other eye. He thought that the hemorrhage was no worse than after an enucleation, but that the drainage was not so good and the blood not having as good egress, made more disturbance, especially as the eyeball was still in place. Schweigger's further observation did not lead him to believe that the operation produced any atrophy of the globe, as claimed by some.

In 1879, Knapp[251] did the operation by way of the space between the superior and internal recti muscles, after the manner of Rondeau,[252] Boucheron,[253] Dianoux,[254] and others, and without cutting a muscle. He employed a double-armed hook to draw the posterior pole of the eye into the conjunctival opening so that the optic and ciliary nerves might be inspected in order to be sure that they were all cut. He took great pains to operate as close to the sclera as possible, as in this area muscles and vascular tissue are largely avoided and the hemorrhage is much less. Chisholm, in later years, operated similarly in a large number of cases with success.

Knapp[255] at this time was impressed with the idea, more or less shared by many observers including Boucheron,[256] Mauthner-Jaeger,[257] Schöler,[258] Dor,[259] and others, that sympathetic ophthalmia passes from one eye to the other by way of the ciliary nerves. The optic nerve was, it is true, severed "so as to make sure" as it were, but the ciliary nerves were regarded as the real offenders. Great pains were taken to sever *all* the ciliary nerves. This is an undertaking not as simple as

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[251] H. Knapp. On the Division of the Optic and Ciliary Nerves. *Arch. of Ophthal.*, Vol. 9, No. 1, 1879, p. 91.

[252] Rondeau. *Idem.*

[253] Boucheron. *Idem.*

[254] Dianoux. *Idem.*

[255] H. Knapp. *Idem.*

[256] Boucheron. *Idem.*

[257] Mauthner-Jaeger. H. Knapp, Further Observations on Optico-Ciliary Neurotomy and Neurectomy. *Arch. of Ophthal.*, Vol. 9, No. 2, 1879, p. 222.

[258] Schöler. *Idem.*

[259] Dor. J. Hirschberg and E. Vogler. On foreign bodies in the interior of the eye; with some remarks on optico-ciliary neurotomy. *Arch. of Ophthal.*, Vol. 9, No. 4, 1879, p. 386.

it seems, when it is remembered, according to Dor[260] and Cruveilhier,[261] that a few ciliary nerves penetrate the anterior portion of the sclera, beneath the recti muscles, one of which, at least, remains after the ordinary optico-ciliary neurotomy.

Another point which consumed considerable attention at that time was the possibility of some, at least, of the nerves uniting after they were cut, a condition evidenced by a restoration of corneal sensibility which, of course, is lost when all nervous connection is severed. Bietti,[262] Mauthner-Jaeger,[263] Boucheron,[264] and others, have seen cases where such reunions have occurred in enucleated eyeballs. Later opinions, however, leaned heavily in the direction of the optic nerve as being the real pathway of pathological connection between the two eyes. Acting upon this theory, therefore, it became necessary to sever the optic nerve and even, as suggested by Schweigger,[265] to remove a large portion of its intra-orbital structure to prevent reunion.

In 1885, Pagenstecher[266] began practising neurotomy, but did not long remain enthusiastic on the subject.

In 1890, de Wecker[267] used it to a considerable extent and employed a right-angled strabismus hook with which to pull the optic nerve forward. He also used compress scissors with which to sever the nerve and compress it, so as to prevent hemorrhage from the central artery.

The Operation of Optico-Ciliary Neurotomy.

General anesthesia should be adopted. The conjunctiva over either the internal or external rectus muscle (preferably the internus) is picked up by forceps just as in a tenotomy for strabismus, and a large, vertical opening made through the conjunctiva. The muscle is drawn out with a strabismus hook, and a suture passed under it and tied around it about ¾ cm. from its insertion. The muscle is now cut between its insertion and the knot, close enough to the knot to leave a large section of the tendon hanging from the eyeball, to serve as a handle to be caught by the forceps for the purpose of pulling the eyeball into positions convenient for the surgeon. The long suture is

[260]Dor. *Idem.*
[261]Cruveilhier. *Idem.*
[262]Bietti. Fage, *loco cit.*
[263]Mauthner-Jaeger. Article by H. Knapp, Further Observations on Optico-Ciliary Neurotomy and Neurectomy. *Arch. of Ophthal.*, Vol. 9, No. 2, 1879, p. 222.
[264]Boucheron. Schweigger. On Resection of the Optic Nerve, *Arch. of Ophthal.*, Vol. 14, Nos. 2 and 3, 1884, p. 223.
[265]Schweigger. *Idem.*
[266]Pagenstecher. Rohmer. La résection du nerf optique d'aprés le procédé de M. deWecker dans l'Ophtalmie Sympathique. *Annales d'Oculist.*, April 1892, p. 249.
[267]deWecker. Article by Fage, *loco cit.*

now given to an assistant who draws the muscle, etc., away from the eyeball, while the operator grasps the tendon with the forceps and rotates the eye in the opposite direction as far as possible to bring the optic nerve as prominently to the surface as possible. A curved double hook piercing into the sclera may, of course, be used instead of the forceps, or in conjunction with it, for this purpose.

The curved scissors are now passed back of the globe, searching for the optic nerve which, when found, should be carefully severed from the eyeball. The neurotomy can, of course, be converted into a neurectomy by exsecting a long piece of the optic nerve, a procedure which is adopted by most operators. The speculum, scissors and forceps should now be withdrawn, the lids closed and gentle but firm pressure exerted upon the eyeball, to prevent hemorrhage. If the bleeding be violent and persistent it causes an irreducible protrusion of the eye-

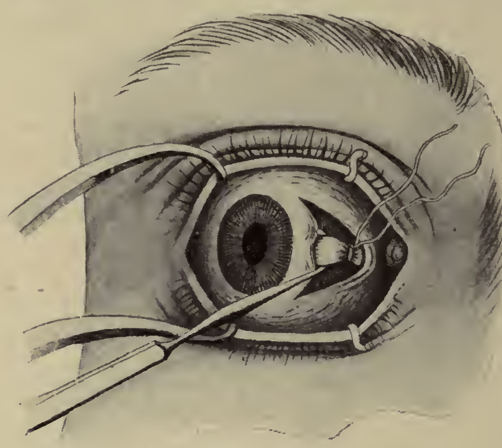

Fig. 267.

Optico-Ciliary Neurotomy. Showing the Conjunctival Incision and the Muscle Tied, the Latter Being Held on a Strabismus Hook.

ball, it should be enucleated, but as a rule the hemorrhage will be controlled in a few moments and further progress can be made.

The speculum should be replaced, the assistant should again pull the muscle away from the eyeball by means of the suture, the tendon should be grasped by the forceps and the eyeball rotated as far as possible in the opposite direction and the ciliary nerves, as they pass into the sclera in the neighborhood of the optic nerve, should all be carefully cut to prevent the transmission of pain, using great caution, as Golovine suggests, to sever that branch of the ciliary nerves which lies beneath the internal rectus muscle. This branch is easily overlooked, but should be cut, else the operation will not bring relief from pain, and this is often the main purpose of the procedure. At the same

time (the bulbar portion of the nerve is now plainly in view) the optic nerve should be cut off level with the scleral surface, if this has not already been accomplished at the original section.

Linds Furgeson[268] claims that the hemorrhagic proptosis can be greatly relieved by passing the curved scissors back of the eyeball, lifting it a little and allowing the blood to escape.

The socket back of the globe should now be thoroughly irrigated with bichloride solution, the muscle caught by fixation forceps, the suture which held the globe liberated and the muscle securely sutured to the tendon with catgut—to preserve its function. The lips of the conjunctival wound should be drawn together with catgut sutures, the

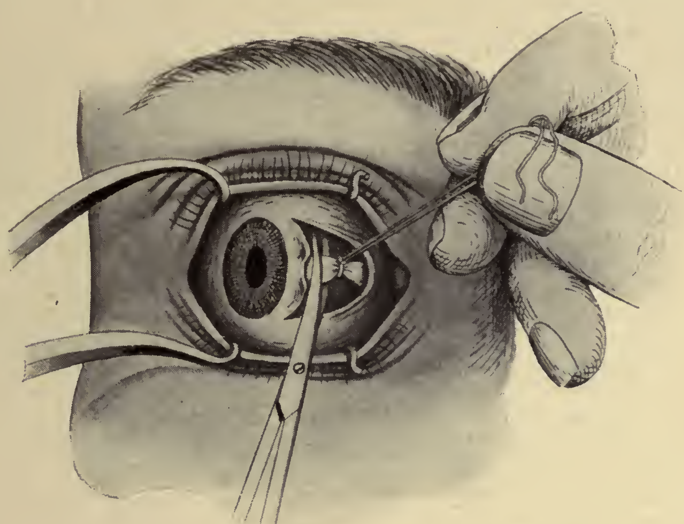

Fig. 268.
Optico-Ciliary Neurotomy. Severing the Muscle.

speculum withdrawn, the lids closed and the operative field and lids abundantly smeared with bichloride ointment.

A firm pressure bandage should be applied and the eye subsequently inspected from day to day.

Some exophthalmus persists for a short time, but it almost always disappears.

The results of the operation are freedom from pain, with an anesthesia of the cornea that gradually disappears.

Corneal ulceration sometimes occurs from defective nourishment, or exposure due to inability to close the lids—as recorded by Landes-

[268] Linds Furgeson. *Trans. Ophthal. Soc. U. K.*, Committee Report, 1898.

berg,[269] Poncet,[270] Leber,[271] Ridard,[272] and others. Tension is usually normal, but the fundus vessels are anemic. Atrophy of the eyeball is not apt to occur. Pain sometimes returns, according to Landesberg,[273] Linds Furgeson,[274] Treacher Collins,[275] and others.

If successful, the operation is certainly excellent, since an eyeball remains, normal in appearance, and perfect in its muscular excursions.

Linds Furgeson[276] has devised a pair of curved scissors with a clamp on its concave surface for cutting the bulbar end of the optic nerve. The scissors and clamp operate simultaneously so that, after the nerve is severed, the globe can be pulled completely around by the clamp.

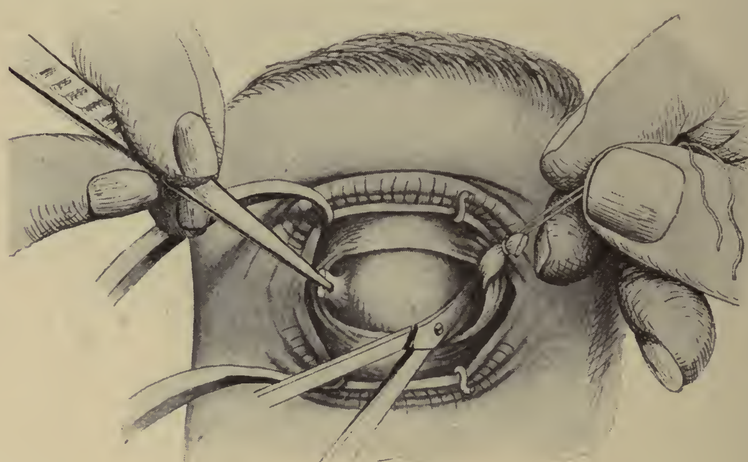

Fig. 269.
Optico-Ciliary Neurotomy. Cutting the Optic Nerve.

Briggs[277] has devised a pair of curved scissors with two sets of blades several mm. apart by which a section of the nerve can be cut out with one compression of the blades. Claws between the scissor blades catch the exsected portion of the nerve; which insures its removal when the scissors are withdrawn.

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[269]Landesberg. *Trans. Ophthal. Soc. U. K.*, Committee Report, 1898.
[270]Poncet. *Idem.*
[271]Leber. *Idem.*
[272]Ridard. *Idem.*
[273]Landesberg. *Idem.*
[274]Linds Furgeson. *Idem.*
[275]Treacher Collins. *Idem.*
[276]Linds Furgeson. *Trans. Ophthal. Soc. U. K.*, 1898. Report of Committee, p. 253.
[277]Briggs. A New Instrument for Performing Optico-Ciliary Neurotomy. *Arch. of Ophthal.*, Vol. 16, No. 1, 1886, p. 37.

Golovine[278] clamps the optic nerve with strong pressure forceps and then divides it in front. He allows the forceps to remain *in situ* about ten minutes, and claims that as a result, there is very little hemorrhage. Golovine also exsects a portion of the optic nerve.

Henry Joseph,[279] in 1904, devised an instrument, something after the form of a tonsillotome, for the purpose of cutting the optic nerve, that may be used either in optico-ciliary or any other form of ocular neurotomy.

Richard Vollert,[280] of Leipzig, in 1909, devised a pair of scissors with false, dull blades in front. These latter are forced forwards by pulling their base backwards. This manœuver forces the eyeball forwards and allows the section of the nerve to be made as far backward

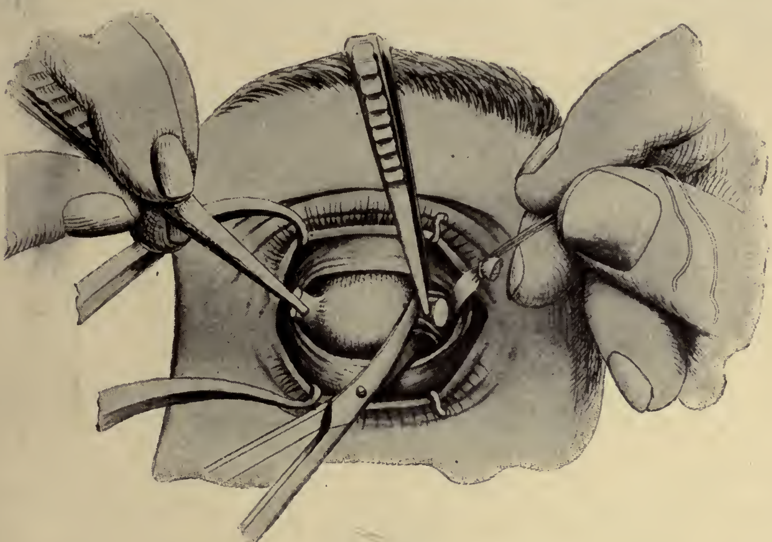

Fig. 270.
Optico-Ciliary Neurotomy. Cutting the Ciliary and Optic Nerves.

as possible. The instrument may be used in neurotomy or in any form of enucleation.

Chisholm,[281] in 1892, advocated a short anesthesia, as his operation takes only a few minutes. He makes, with scissors and forceps, a short, horizontal incision in the conjunctiva along the lower border of the internal rectus muscle. Scissors are inserted beneath the mem-

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[278]Golovine. Neurectomia Optico-Ciliaris bei Glaucoma absolutum. *Zeitschr. f. Augenheilk.*, Vol. 5, June, 1901, p. 414.

[279]Joseph. Crochet-neurotome pour sectionner le nerf optique au fond de l'orbite. *Arch. d'Ophtal.*, Nov., 1904, p. 715.

[280]Vollert. Personal communication.

[281]Chisholm. Resection of the optico-ciliary Nerves. *Journ. Am. Med. Assoc.*, Sept. 10, 1892.

brane to open the space of Tenon. A double-pointed, curved hook inserted beneath the capsule, engages the sclera. The eyeball is rotated outwards, bringing the optic and ciliary nerves within easy reach. Strong, curved, enucleation scissors are now passed back of the eyeball and both nerves are severed. A compress bandage is quickly applied after the ordinary dressings, to prevent excessive hemorrhage. It is kept in place for one day.

Chisholm claimed extraordinarily good results, but this statement should be taken guardedly as many surgeons have abandoned his operation on account of excessive bleeding, corneal necrosis, bulbar atrophy, etc.

In a personal communication from Menacho, of Barcelona, March 2d, 1910, he advocates making the circum-corneal incision and afterwards cutting the internal and external recti muscles quite a distance

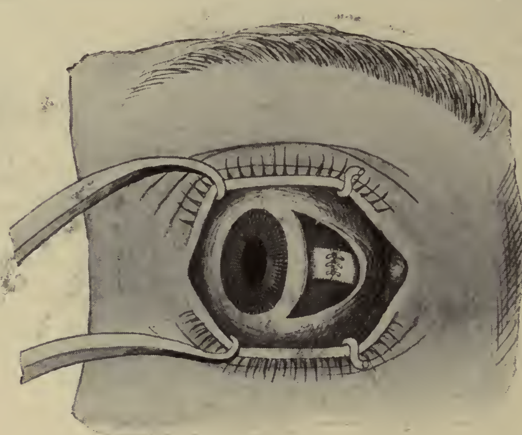

Fig. 271.
Optico-Ciliary Neurotomy. The Sutured Muscle.

back from the globe. A suture is then passed through each end of the severed muscle. The sutures transfixing the tendons next to the sclera are held in one hand while the eyeball is pulled forward as far as possible, thus lifting it from its bed. This enables the operator to pass the scissors back of the eyeball and perform the neurotomy or neurectomy, after which the cut tendons are sutured together. Menacho claims for the operation simplicity and speed.

Ernest Hall,[282] in 1895, proposed as a substitute for enucleation the following procedure:

[282]Ernest Hall. Evisceration of the Eyeball with Sclero-optic Neurectomy. *Am. Journ. of Surg. and Gynecology.* Vol. 8, July, 1896, p. 96. Enucleation of the eyeball with sclero-optic neurectomy, *Dominion Med. Monthly,* Vol. 7, 1896, p. 495. A Method for Partial Resection of the Eyeball and of the Optic Nerve, *Annals of Surgery,* 1898, Vol. 27, p. 640.

"The scissors having been inserted about 25 mm. behind the sclero-corneal junction, sufficiently to include the ciliary body, a complete section is made, so removing the whole front of the eyeball. The vitreous is then evacuated and the retina and choroid removed by curette. The hemorrhage is profuse but controlled by hot water and pressure. Then the speculum is inserted within the ball and so made to hold the eyelids and edges of the sclerotic opening. The optic nerve is grasped with toothed forceps and scissors, or a long slender knife inserted as close as possible to the nerve to avoid wounding the ciliary arteries, and a circular incision made in the sclerotic, freeing the optic nerve. The nerve is then drawn forward and severed about 25 mm. from the sclerotic and conjunctiva. A piece of gauze is inserted in the sclerotic and conjunctiva closed vertically so as to give normal tension to the internal and external recti."

By this operation the ciliary region is excised in front and the optic nerve, etc., behind, thus removing the two principal sections of the eyeball whence trouble may be expected. The central zone of the sclera, with its muscular attachments, is undisturbed.

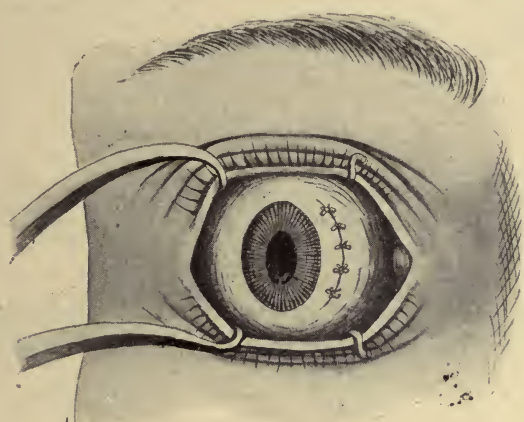

Fig. 272.
Optico-Ciliary Neurotomy. The Sutured Conjunctiva.

Huizinga,[283] in 1900, proposed an operation which he called "Evisceroneurotomy." It is a combination of evisceration and optico-ciliary neurotomy.

A Mules' globe may be inserted or not, and he claims complete immunity from sympathetic ophthalmia. In this operation the anterior portion of the globe is abscised by knife, scissors and forceps; the contents of the globe are removed exactly as in the ordinary evisceration operation. The bulbar opening is enlarged laterally by splitting the sclerotic up to the insertions of the internal and external recti muscles. The peculiar feature of his operation is as follows:

"While an assistant keeps the mouth of the wound widely open, a pair of forceps is introduced into the inside of the ball, through the opening made by amputation of the cornea, and the sclerotic coat is caught about

[283] Huizinga. Eviscero-Neurotomy. *Journ. Am. Med. Assoc.*, Feb. 17, 1900.

midway between the equator and the posterior pole, and button-holed with blunt-pointed scissors.

This opening is then enlarged laterally, parallel with the equator, until it has encircled one-half of the ball. A blunt, curved enucleation scissors is then introduced through this opening and passed back of the globe, and the optic and ciliary nerves are severed. Having thus loosened the eyeball posteriorly, this part can then be drawn forward up to the corneal opening by partly everting the sclerotic from behind by the aid of forceps, and that part of it, including the nerves, is removed by continuing the cut parallel with the equator until it extends entirely around the eye. In this manner the posterior segment of the eye, a section somewhat larger than the cornea, is removed, and all nerve connection thoroughly and permanently obliterated, while the rest of the sclerotic with its muscle attachments is allowed to remain.

The introduction of an artificial vitreous is very desirable, notwithstanding the fact that it is not always retained and the difficulty occasionally experienced to obtain prompt and perfect union by first intention. Where such unfortunate conditions do not obtain, and they are in the majority, the results are so much better for a prothesis that I believe this practice

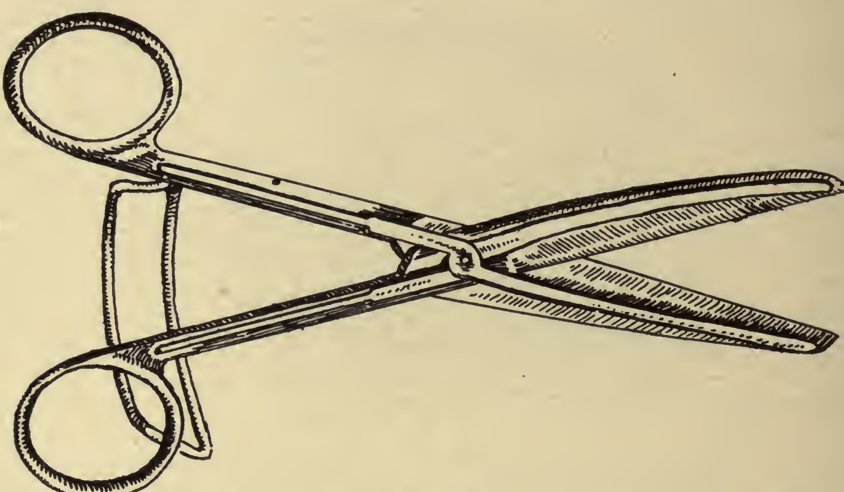

Fig. 273.
Scissors of Vollert.

would be more generally adopted if some material could be obtained that is more suitable to the purpose than either glass or metal.

The wound is closed with fine silk sutures, and the after-treatment is the same as in evisceration. The local reaction following this operation has in no case been as severe as that following simple evisceration. In fact, I should say that it has been no more severe than after enucleation.

This operation is strictly in accord with what I consider one of the first rules in surgery, viz., to obtain the maximum in results by the removal of the minimum of tissue.

In conclusion: 1. This method, with the use of an artificial vitreous, leaves as perfect a stump as after Mules' operation. 2. It prevents absolutely the dangers of sympathetic inflammation. 3. The local reaction appears to be no greater than after enucleation. 4. We obtain the maximum in results by the removal of the minimum of tissue. 5. We obtain, besides this, all the advantages claimed for Mules' operation, as well as those of enucleation without their disadvantages."

Shortly after the publication of this paper, Huizinga began a

series of operations on dogs and considerably modified his previous procedures. His improved method is as follows:

"Having introduced a speculum and taken the ordinary precautions to guard against infection, the eye is drawn inwards and upwards as far as possible so as to expose the external inferior quadrant. With a small scalpel the sclerotic is pierced about a quarter of an inch posterior to the sclero-corneal margin and just below the insertion of the external rectus. This incision is carried backwards meridionally up to the entrance of the optic nerve. The cornea is not amputated but left intact. The contents of the eyeball are carefully removed and its interior thoroughly cleansed. I find that an ordinary eye speculum introduced into this wound assists in keeping its edges apart and greatly facilitates the work. A circular section of the posterior portion of the sclerotic, just large enough to include the optic and ciliary nerves, is then removed through the opening in the globe and the end of the nerves amputated. After all hemorrhage has ceased, a fenestrated metal ball, the largest size that can possibly be accommodated, is introduced. The edges of the wound in the sclerotic are closed with catgut sutures, which are covered by the conjunctiva being drawn over them and sutured with black silk.

The local reaction is comparatively slight. The cornea soon loses its characteristics and becomes lustreless and opaque. In about six or eight

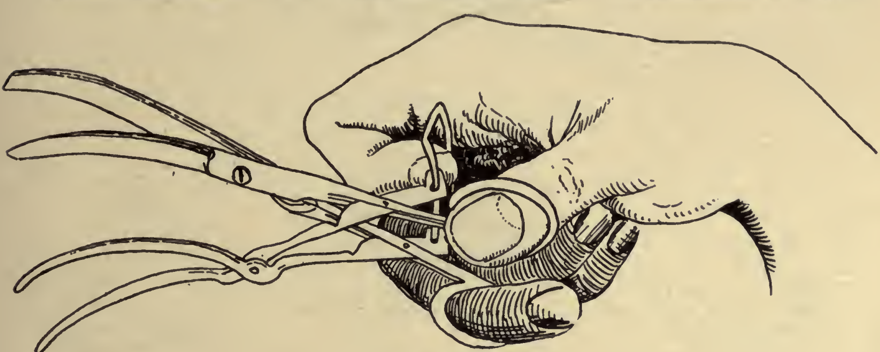

Fig. 274.
Scissors of Vollert.

weeks after the operation the cornea is tattooed so as to resemble as nearly as possible a normal eye—i. e., the center of the cornea black to resemble a pupil, and around this circle of such color as may harmonize with that of the iris of the other eye.

The results have been fairly satisfactory and have encouraged the hope that it may be possible to remove as much as may be necessary in an offending organ and yet retain a fairly presentable eye without the necessity or inconvenience of wearing an artificial shell. In size the globe decreases a little. The sclerotic remains slightly congested for a time, giving the appearance of an inflamed eye. Subsequent enucleation has shown that the interior of the metal sphere became filled with new tissue entering in through the opening in the posterior part of the sclerotic and through the fenestræ of the metal ball."

Nicati,[284] in 1903, proposed an operation which is quite similar in its process to that of Huizinga. It is called "partial ablation of the ocular globe by the process of sub-enucleation." He operates as follows:

[284] Nicati. De l'ablation partielle du globe oculaire par le procédé de la subenucleation. *Arch. d'Ophtal.*, June, 1903, p. 347.

"A horizontal or vertical incision is made into the conjunctiva on the inner side of the globe. The adductor muscle is seized, divided through its tendon and guarded by a catgut suture which is passed through the tendon and the conjunctiva. The capsule is separated above and below and the optic nerve is sectioned in the ordinary manner. The posterior pole of the eyeball is seized with a tenaculum and is drawn forward. It is separated from the oblique muscles and is drawn through the conjunctival opening, after which the posterior portion of the globe is exsected up to the insertion of the rectus muscles. The conjunctival opening is closed, and the tendon of the internal rectus muscle is secured. An accumulation of blood back of the cornea forces the eyeball forward but this, he says, is removed by compression.

Convalescence is more rapid than in total enucleation, and the results are an excellent stump with the conjunctiva entire.

Sympathetic ophthalmitis is avoided, the anatomo-pathologic collectors alone being the losers."

L. Müller,[285] in 1908, practised a similar operation.

Nicati's statement should not be allowed to pass unchallenged as sympathetic ophthalmia is not always averted, as evidenced by cases

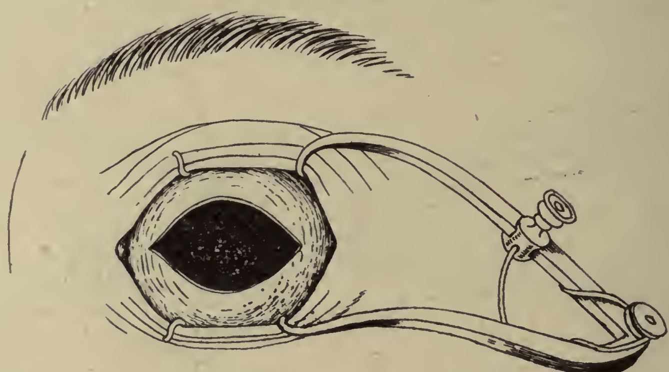

Fig. 275.
Preparatory Evisceration for Huizinga's Operation.

cited by Trousseau[286] and Rohmer[287] in 1893, Pflüger,[288] Clausen,[289] Schweigger,[290] Krones,[291] and others, after the performance of this operation.

THE TRANSPLANTATION OF ANIMALS' EYES INTO HUMAN SOCKETS.

The transplantation of a rabbit's eye into the human orbit has up to the present time resulted in little more than the exploitation of a

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[285]Müller. Die Resektion des Augenapfels, *Wiener Klin. Wochenschr.*, Dec. 3, 1908.

[286]Trousseau. Un cas d'ophtalmie sympathique. *Mém. de la Soc. d'Ophtal. de Paris*, April 7, 1891.

[287]Rohmer. La resection du nerf optique d'apres le procédé de M. de Wecker. *Annals d'oculist.*, April, 1892.

[288]Pflüger. International Med. Congress, Paris, 1900.

[289]Clausen. Rohmer, *Annales d'Oculist.*, April, 1892.

[290]Schweigger. *Idem.*

[291]Krones. *Idem.*

surgical curiosity, but extending some slight encouragement for future investigation. While a few experiments have produced movable, and more or less prominent, stumps by such procedures, no case has as yet been reported where vision has been produced and in the very nature of things it is exceedingly improbable that such a result will ever be attained. It must be mentioned, however, that S. Zervos, *(Grèce Médicale,* Vol. XII, No. 1 and 2, 1909) narrates some wonderful results in transplanting testicles, kidneys, spleens and eyeballs from one animal to another. He claims that eyes from young animals can be successfully transplanted and that they will resume their functions. Certainly, further proof is necessary before such astounding claims will be accepted. It is difficult to see how the stump-producing

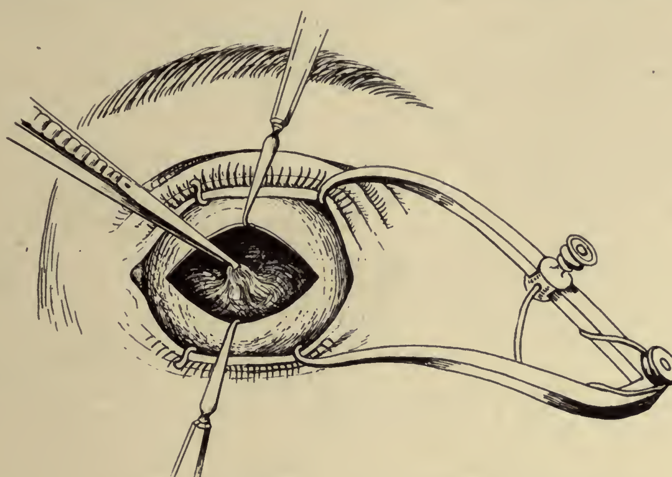

Fig. 276.
Operation of Huizinga. Grasping the Sclera from the Inside of the Eye.

results of these experiments are really superior to a well-performed enucleation, where the muscles, conjunctiva, etc., are all sutured together, as described in earlier portions of this Chapter, since under the most favorable circumstances the implanted eyeball shrinks to one-half or one-third of its original volume. The results certainly cannot be compared in their cosmetic quality to a Mules' operation.

Some operators merely adjust the rabbit's eyeball into the space just vacated by the human globe and attach the muscles, conjunctiva, etc., to the implanted sphere; others also unite the ends of the two optic nerves.

The first experiment was made by Chibret,[292] May 4th, 1885, on a

[292]Chibret. *Bull. de l'Academie de Médécine de Paris.* May 28, 1885. Also, *Révue Générale d'Ophtal.,* May 31, 1885.

girl of seventeen years. He implanted a rabbit's eye by suturing the patient's conjunctiva to the rabbit's cornea. The cornea, of course, sloughed, as might have been expected, and the operation was a failure. Terrien,[293] a little later in 1885, reported another failure and Rohmer,[294] still later in 1885, reported another. Bradford,[295] still later in 1885, reported a fourth case, which he claimed as successful. This operator united the two optic nerves, and the two conjunctivæ, as well as the muscles of the orbit to the implanted globe. The records of this case, however, disclosed the fact that within a year the cornea became opaque, wrinkled and sclerosed, and while no pain, inflammation or discharge was present, it was deemed best to remove the eye. Terrien[296] later, in 1885, followed Bradford's plan, but did not succeed.

May,[297] in 1886, performed a valuable series of experiments on 24

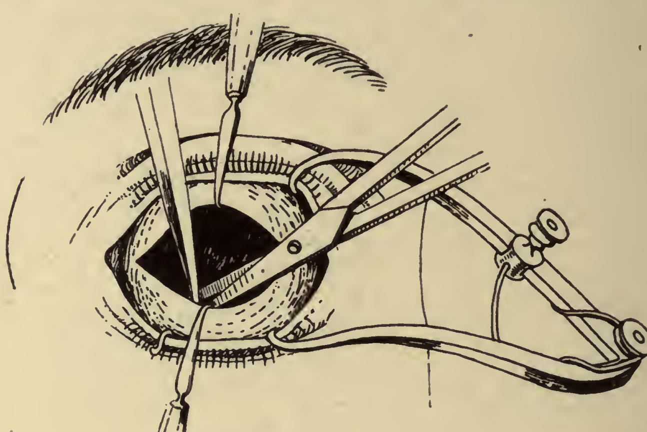

Fig. 277.

Operation of Huizinga. Cutting Away a Portion of the Sclera from the Inside of the Eye.

rabbits into whose sockets he implanted the eyeballs of other rabbits. He established the fact that the operation is entirely feasible, but whether it is profitable or not is quite another matter when we consider that the rabbit's eye is much smaller than the human eye and that after a successful operation it shrinks to from one-half to one-third its original size.

May says that the tissues of the socket and the implanted eyes heal promptly and that muscular movement is evident in from 3 to 16

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[293]Terrien. Report to the *Société de Chir. of Paris*, 1885.

[294]Rohmer. Beard's *Ophthalmic Surgery*, 1910, p. 467.

[295]Bradford. A Case of Enucleation with Replacement of the Human Globe by that of a Rabbit. *Boston Med. & Surg. Journ.*, Sept., 1885, p. 269.

[296]Terrien, *loco cit.*

[297]May. Enucleation with Transplantation and Reimplantation of Eyes. *N. Y. Med. Record*, May 29, 1886, p. 613.

days. He had sloughing in 9 cases, but some kind of an eyeball was preserved in all cases; small in some and larger in others. He claimed that the optic nerves became united in all cases.

In 1901 Lagrange[298] instituted some experiments in grafting a rabbit's eye into a human socket. He warns surgeons not to be influenced by Rohmer's failures as his technic was faulty, he having deposited the rabbit's eye into the human capsule of Tenon before bleeding had ceased. He used purse-string instead of interrupted sutures, with the rabbit and human muscles nicely approximated. He regards the following rules as essential to success:

"1. That, as each rectus is cut, a thread be passed through it to prevent its retraction.
2. Following enucleation, that the eye be not inserted until all hemorrhage has ceased.
3. That an eye of a *young* rabbit be selected.
4. That the opposite muscles be drawn into apposition by appropriate sutures.
5. That the sutures in the conjunctiva be close together and be allowed to remain a week.
6. That the most careful antisepsis be carried out."

In 1905 Lagrange[299] still further improved his technic, by protecting the cornea from those influences which favor its necrosis. His features of improvement are enumerated as follows:

"The rabbit's eye is placed into Tenon's capsule with the cornea turned *downward* and then the several muscles of the patient's eye are sutured to the posterior pole of the rabbit's eye. Rolling up of the muscles can be prevented by flattening them out. This method of implantation should not be used after enucleation on account of iridocyclitis and panophthalmitis, where the capsule of Tenon is implicated in the process. The implanted eye shrinks in the course of time, but there usually remains enough of a stump for the artificial eye to facilitate its mobility. Out of 11 cases observed, 8 showed a very good result. The longest time of observation was 4 years."

In 1907 Lagrange[300] modified his operation by placing the eye of the rabbit *directly backwards,* as the sclerotic is better able to withstand the pressure of the threads than the cornea.

Wicherkiewicz,[301] reports the results of 35 implantations of the rabbit's eye, which he performed in his clinic. His conclusions are as follows:

"1. The implanted and sutured eyeball becomes well attached to the straight muscles and acquires normal movements.
2. The course of healing, considering the operation, is comparatively short.
3 The connection of the implanted globe with the surrounding tissues

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[298]Lagrange. Heteroplastie orbitaire par la greffe d'un oeil de lapin dans la capsule de Tenon. *Ann. d'Oculist.*, 1901, p. 369.
[299]Lagrange. De l'amélioration de la prothèse oculaire par la greffe de l'oeil de lapin. *Ann. d'Oculist.*, May, 1905, p. 391.
[300]Lagrange. De l'amélioration de la prothèse oculaire par la greffe d'un oeil de lapin. *Arch. d'ophtal.*, March, 1907, p. 150.
[301]Wicherkiewicz. The Transplantation of the Rabbit's Eye into Tenon's Capsule. Trans. from *Pastep. Okulist.*. No. 7, 1908.

is intimate, as, for instance, a recurrent neoplasm, not only the orbital tissues but the rabbit's eye itself grows fast.

4. In course of time the implanted globe becomes one-half or one-third the original size.

5. The older the subject the greater is the shrinking of the globe, which sometimes becomes so atrophic that it cannot be felt.

6. In no instance has the implantation given rise to sympathetic symptoms in the other eye."

From longer observation Wicherkiewicz is inclined to restrict this heteroplasty to children or young subjects, on account of the atrophy of the implanted globe. In 1909 he followed the plan of Lagrange and

Fig. 278.
The Socket after the Implantation of a Rabbit's Eye.

advocated the turning of the cornea directly backward to protect the cornea, by keeping it warm and guarding it from outside influences. It was also found that in this position better motion could be obtained than if the eye was turned downward, as first proposed by Lagrange.

I have never performed this operation, but would suggest that the cornea may be amply protected by placing it well forwards within the capsule of Tenon, and then uniting with catgut sutures the muscles of the patient to the stump of muscles left on the rabbit's eye. The

undermined conjunctiva might then be sutured over the implanted eyeball.

GIFFORD OPERATION FOR SIGHTLESS STUMPS.

Gifford (*Archives of Ophthalmology,* Vol. 31, No. 2) has suggested an operation for the protection of the cornea, in some sightless eye stumps, where the patient will not consent to an enucelation or evisceration, and yet desires to wear an artificial eye but is deterred from so doing on account of a sensitive cornea. His remarks and directions for operating are as follows:

"I believe that many sightless stumps are worth preserving, as they make the best possible support for an artificial eye; and as being entirely harmless if, after once becoming quiet, they can be kept from being infected. Where such a stump has any considerable amount of cornea left, this sometimes becomes irritated when an artificial eye is worn, and often drives the patient to the oculist with the request that the stump be removed in order that a shell may be worn with comfort. In another class of cases, the amount of cornea left is so small that it would not be irritated by the artificial eye, but, having been penetrated either by an ulcer or a wound, bits of the iris tissue are exposed in the scar so as to become not only a source of irritation, but possibly of deep-seated and dangerous infection. In the third class, the eyeball may be quite natural-looking, but on account of its distorted nutrition, either from glaucoma or from some other cause which impairs the vitality of the corneal epithelium, it is subject to frequent attacks of corneal ulceration which render the ball a nuisance. In all of these cases I have been accustomed for the last six years to cover the cornea either with a conjunctival flap, a Thiersch flap, or an epithelial lip flap. Where, as in the majority of cases, conjunctiva is used, the membrane is excised around the lower half of the cornea for an area about 3-16 of an inch wide at the sides, and ⅛ inch below. Above this zone the membrane is dissected free from the globe as far as the upper fornix in the neighborhood of which a cross cut is made through the membrane to allow it to be slid down over the cornea without putting too much tension on it. Three sutures below are generally sufficient, but these should be put well into the episcleral tissue, nearly as deeply as in the advancement of one of the straight muscles. It may be asked why not accomplish the same thing by dissecting up the conjunctiva both above and below and sewing it together in a straight line across the centre of the cornea. This is the method which first occurred to me and which I tried without success, both on men and rabbits. It proved to be practically impossible to bring enough raw surface from each side into contact to produce a firm union. As soon as the stitches came out, the conjunctiva slipped gradually back, leaving the cornea nearly as much exposed as before. This is the reason for putting the stitches into the episcleral tissue after denuding the sclera below the cornea. Unless this is done, the tension on the upper flap is apt to pull up the conjunctiva from below, so that the line of sutures lies across the cornea and firm union does not take place.

Where, from any cause, the conjunctiva is atrophic and the space for an artificial eye would be too much limited by the operation just described, I use an epithelial lip flap (i. e., a thin flap shaved from the lip with a razor), or a Thiersch flap. The conjunctiva having been dissected up for ⅛ of an inch around the cornea, and the cornea having been scraped (especial care being taken in the neighborhood of the limbus), the flap is spread out carefully over the cornea and tucked under the loose conjunctiva on all sides. It is well to bandage both eyes for twenty-four hours after these operations. I have used the Thiersch flap for this purpose only once, because, although it healed on perfectly, the accumulation of dead epidermis on its surface caused some irritation and I scraped the skin flap off and substituted a lip flap for it. I think, however, that the irritation could have

been avoided if the patient had wiped off the dead epidermis once or twice a week (as I have since learned to teach other patients to do, where Thiersch flaps have been substituted for conjunctiva in other sorts of operations); and the ease with which larger Thiersch flaps can be obtained, inclines me to give them another trial where a nearly full-sized cornea requires to be covered.

It should not be understood that I propose these operations as substitutes for evisceration or enucleation in actively infected globes. But rather in the class of cases in which the patient comes to the oculist with a perfectly quiet stump over which a shell cannot be worn on account of the irritation of the cornea; or on account of the danger of irritating and infecting exposed bits of iris tissue; or where the stump is irritable solely from the degeneration of the corneal epithelium, one or the other of these operations does excellent service in doing away with the necessity for a more radical operation and in preserving the best kind of support for an artificial eye. Moreover, it is readily accepted by some patients who will not consent to an evisceration or an enucleation."

Dianoux, in 1902, proposed, to avoid an enucleation, the following operation for *hydrophthalmus:*

"The cornea is slowly cauterized in lines radiating from its center to the depth of two-thirds its thickness. A cone with a radius of 2 mm. is then formed in its center, the apex of which is perforated, allowing the aqueous humor to escape. A bismuth compress and bandage dressing are applied and retained for a period of three days, after which cleansing and bi-daily instillations of cocaine-eserin solutions, followed by the application of compress bandages, are practised for several weeks' time. If an excess of tension is observed, massage is employed twice daily. If necessary the operation may be repeated. Tattooing of the globe may increase the value of the method from an artistic standpoint."

CONCLUSIONS.

It is the desire of the Editor of this *System* to have each chapter contain not only instructions concerning the best and most approved operative procedures, but also a record of the evolutionary history of the subjects. In harmony with this wish it has been my purpose in this chapter to give space to practically *all* operations having for their object the removal of all or any portion of an eyeball.

Many of the recorded operations are, in my opinion, practically worthless, and, perhaps, have never been performed except in the mind of the writer, but they are a part of the history of this subject and should, therefore, occupy a portion of my space. It is not my purpose to condemn any of them in print, no matter what my opinion of them may be, as I recognize the fact that discarded surgical procedures are sometimes resuscitated, and remodeled; *then* they *may* acquire a permanent position in practical surgery.

Before leaving this important subject, let me say, that probably no operation will ever deprive some form of enucleation of its well deserved popularity. Other procedures, such as evisceration, Mules' operation, etc., are doubtless useful and desirable under certain conditions, but enucleation will probably ever remain a favorite with most surgeons. This must, almost necessarily, be the case since a large proportion of eyes requiring removal are suffering from some form

of anterior ocular suppuration, when any procedure short of total extirpation is accompanied by more or less risk. Besides this, many cases of eyeball removal are necessitated on account of ocular or orbital tumors (especially when malignant) and this condition demands complete excision of the eyeball.

Again, when sympathetic ophthalmia is present or threatened, no operation is so reliable in its results as enucleation. This statement is especially to be emphasized if two weeks or more have transpired since the original traumatism, as by that time (C. F. Heerfordt and other observers) dangerous migration may have occurred and any operation which does not sever the optic nerve as far back as possible may be insufficient to check the further progress of disease. If the injured eye is seen before two weeks have elapsed it may be regarded as safe to perform some other operation, such as evisceration or Mules' operation.

These and other pathological conditions, such as badly lacerated and excessively shrunken eyeballs, removable eyeballs in old people, etc., constitute a majority of cases calling for some form of extirpation and it becomes quite apparent to an unbiased mind that enucleation is, and must remain, the most frequent of the operations considered in this chapter.

In this connection it should likewise be said that the old-fashioned Ferrall or Bonnet operation, in which no effort is made to preserve muscular activity of the stump, so generally done now and in the past, should be employed with much less frequency in the future. Some operation in which the conjunctiva, capsule and muscles are sutured together for the purpose of producing a prominent and movable bed upon which a well-selected artificial eye may rest and move is the operation of election. The Ferrall or Bonnet operation will probably always have a place in ophthalmic surgery, especially when a severe orbital infection calls for open drainage and when malignant orbital tumors require thorough orbital exenteration, but in practically all other cases every structure possible should be preserved. In selecting an operation where muscular activity of the stump is preserved, one of the procedures described in this chapter, where the muscles are firmly secured, before tenotomy is performed, should be chosen, for if the muscle is cut and allowed to shrink into the socket, it is difficult to pick it out from the surrounding tissue and secure it with a suture.

Evisceration is particularly applicable to those cases of ocular or orbital suppuration that have extended into the posterior portion of the globe or have invaded the orbital tissues. Most operators perform enucleation even under these circumstances, but statistical warnings render this operation open to criticism.

Mules' operation may be done except in cases of ocular or orbital suppuration, sympathetic ophthalmia, malignant tumors and badly lacerated or shrunken eyeballs. Great care should be exercised to eviscerate thoroughly the ocular contents, purify the internal scleral walls, select a sufficiently small glass or gold globe and to suture thoroughly the scleral opening.

The implantation operations of Frost, Lang, Morton and Oliver are indicated wherever Mules' operation is applicable; also in much lacerated and shrunken eyeballs, possibly, also, in sympathetic ophthalmia.

Further experiments in the implantation of fatty tissue should be encouraged.

The delayed implantation operation of Fox may be used in any orbit where an improved bed for a prothesis is desired and where sufficient tissue is present to render the procedure possible.

If optico-ciliary neurotomy or neurectomy is useful it is in painful, sightless, glaucomatous eyes, and for sightless eyes where a chronic, non-traumatic iridocyclitis is present.

If abscission or complete keratectomy is ever justified, it is in patients with anterior staphyloma, especially in children.

INDICATIONS FOR REMOVAL OF THE EYEBALL.

The following conditions usually call for some form of eyeball removal: 1. Severe injuries (especially involving the ciliary region) where good judgment dictates the operation.

2. Unremovable, intraocular foreign bodies.

3. Suppurative panophthalmitis.

4. Blind eyes producing sympathetic irritation, or sympathetic ophthalmia in any stage.

5. Eyes (still retaining vision) that are beginning to produce sympathetic ophthalmia or marked sympathetic irritation. It should be remembered that where pathological processes have been transmitted before enucleation has been performed, the operation is powerless to prevent sympathetic ophthalmia. If sympathetic ophthalmia does not occur within four or five weeks after enucleation, it is unlikely to occur at all.

6. Eyes possessing intra- or extraocular malignant, tubercular or syphilitic growths that cannot be completely removed either by treatment or by operation.

7. Persistently painful or irritable stumps left after eyeball removals, where a complete enucleation has not been performed; also shrunken eyeballs that are painful and irritable.

8. Suppurating sockets intractable to other treatment.

9. All blind, persistently sensitive and irritable eyeballs.

10. Total corneal or extensive bulbar staphyloma.

11. Buphthalmos and hydrophthalmos.

12. Blind, deformed eyeballs.

13. Painful, absolute glaucoma not relieved by other procedures.

14. Profuse, painful, intractable intraocular hemorrhage. This usually proceeds either from an accident or from an operation.

15. Blind or nearly blind eyes with a dislocated lens or detached retina, where inflammation, pain and visual defects unite to make life burdensome.

16. Cranial inflammations caused by fractured orbital roofs, where the seat of trouble cannot be reached, and where life may be at stake.

It is generally conceded that little, if any, benefit results from the enucleation of a primarily diseased or injured eye after a plastic irido-choroiditis has developed in the second eye, although many surgeons believe that sympathetic ophthalmia runs a milder course and is less likely to recur if the exciting eye has been removed. Indeed, if any vision remain in the primarily affected eye, it is wiser to retain this eye, since prognosis as to eventual sight is better in it than in the secondarily affected eye. It should not be forgotten that the surest preventive against sympathetic ophthalmia is the prompt removal of really dangerous eyes, especially if vision and beauty have already been destroyed.

ARTIFICIAL EYES.

Centuries ago artificial eyes, or imitation eyes, were used, as all frequenters of museums know, in mummies and statues. Subsequent to this history tells us that for patients with empty or shrunken sockets, presentable artificial eyes were provided. (See the Chapter on Minor Surgery.)

Until Snellen's[302] suggestion in 1898, the shape of the prothesis remained much the same, even though enucleation (proposed and practised from 1841 and 1842) did away with the backing or support of the artificial shell, which was such a strong factor in the production of a natural and life-like appearance. The original artificial shell, while well suited for the purpose for which it was proposed, viz., to be worn over an atrophied eyeball, was not adapted to the use of a socket from which the eyeball had been removed. A large space between the shell and the posterior wall of the orbit existed in which tears, mucus, etc., could accumulate and produce unhealthy condi-

[302]Snellen. Glaserne Augäpfel als oculäre Prothesen. *Klin. Monatsbl. f. Augenheilk.*, 1899, p. 71. Also, *Ophthalmic Review*, Dec. 1, 1898, p. 247.

tions. The thin edges of the glass frequently injured the delicate conjunctiva and scars and granulations were produced. Besides this, inasmuch as nothing touched the back of the shell and it was supported merely by its peripheral edges resting on the periphery of the orbit, very little motion could be obtained and the prothesis became merely a dead, almost motionless, imitation of an eye, a thing which deceived no one and was a constant source of mortification and irritation to its wearer. To do away with at least some of these defects, Snellen began experimenting on artificial eyes. At first he filled the large posterior concavity with plaster of paris and then with gutta-percha. The sharp edges were rounded and the back of the prothesis was made either convex or concave, according to the outlines of the stump.

At Snellen's suggestion, Müller,[303] in 1898, made some eyes blown so that the posterior surface of the shell was more or less convex in-

Fig. 279.
Profile View of an Ordinary Artificial Eye.

Fig. 280.
Profile View of a Snellen Eye.

Fig. 281.
Profile View of a Snellen Eye.

stead of concave as heretofore, and the space between the front and back of the eye was air-blown, which, of course, made the shell very light, not weighing, on an average, more than 3 grm. These eyes have become very popular and are much worn, especially when an excision or simple evisceration has been performed. They are very comfortable, have fair motion, and present quite a life-like appearance.

Milliken in 1904, recorded a peculiar accident happening to one of these reform eyes. The patient suddenly heard a loud report followed by the trickling of blood down her cheek. Upon removing the Snellen eye she found it was broken, apparently without cause. The explosion was probably due to the vacuum in the shell; although it is not intended to produce a *complete* vacuum in the shell's interior.

J. L. Borsch[304] claims that several years before Snellen published the account of his "Reform-Auge," his father, an optician in Philadelphia, had Müller construct some artificial eyes essentially the same as Snellen's. These were presented by Schwenck[305] to the Ophthalmic section of the College of Physicians and Surgeons of Philadelphia,

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[303]Müller. *Ophthalmic Review*, Dec., 1898. Also, see the article by J. L. Borsch, The Closed Artificial Eye, *Ophthalmic Record*, 1901, p. 231.

[304]Borsch. The Closed Artificial Eye. *Ophthalmic Record*, May, 1901, p.

[305]Schwenck. *Trans. Sec. Ophthal., Coll. of Phys., Phila.*, Feb., 1897.

231.

and are referred to in their *Transactions* for February, 1897. Borsch commenced his experiments by attaching a gold spring behind an ordinary prothesis for the purpose of pushing the shell as far forward as possible. This plan was soon abandoned on account of the difficulty in keeping the spring clean. He then filled in the posterior concavity with wax, which proved so satisfactory that in 1894 he had Müller make some eyes that were hollow and rounded posteriorly. These proved satisfactory and were used in de Wecker's clinic in 1894.

It should not be forgotten, however, that the improved Borsch-Snellen eye will not be a thoroughly life-like eye when placed in the large, empty socket which follows a Ferrall or Bonnet operation.

When the muscles and conjunctiva have not been sutured together and good motion is to be imparted to *any* artificial eye, activity of the recti muscles must be maintained by some of the substitute operations which have been described in this section. It must, of course, not be forgotten that a little motion is retained by a Ferrall or Bonnet

Fig. 282.
Artificial Eye with Gold Spring.

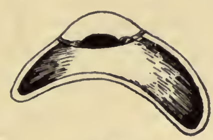

Fig. 283.
Snellen's Improved Eye.

stump, because, while the muscles have been separated from the eyeball, they still retain some connection to Tenon's capsule, so that the stump is not utterly lifeless and motionless.

In 1907, Grossman[306] proposed that artificial eyes should be made with bulgings at their upper anterior surfaces, to relieve the appearance of enophthalmus that exists at the upper periphery of the upper lid. Such eyes should be made to order, to be suitable for each individual case.

Murdock places an oval ball of toughened glass in the socket from which an eye has been removed by an ordinary enucleation and over this places the artificial eye. He reports improvement in the rotation of the shell.

Dabney,[307] in 1909, wrote me of an unusual experience he had with a patient whose eye had been removed and whose socket had subsequently shrunk so that she could not wear an artificial eye. He secured a set of glass balls, the smallest of which he bandaged into the socket, increasing the size of the ball each day until the socket became

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[306]Grossman. *Trans. of the 11th Internat. Med. Cong.* Also. An Improved Form of Artificial Eye., *Brit. Med. Journ.*, Nov. 2, 1907.
[307]Dabney. Personal Communication, 1909.

so large she could be fitted with a prothesis. For many months it was necessary to retain in the socket a large ball at night, but this after a while became unnecessary.

That artificial eyes may appear to the best advantage, it is well to have them made to order by some of the manufacturing firms who make a specialty of this sort of work. Orbital irregularities and ocular peculiarities may in this way be considered, and much more satisfactory results obtained. Still, well matched eyes may frequently be puchased ready-made from the stock of some optician or instrument dealer.

Morton, in 1892, reported a case of a man who wore an artificial eye and who contracted gonorrhea. He infected his socket by means of his fingers and the prothesis.

CHAPTER II.

THE OPERATIVE TREATMENT OF EPIBULBAR TUMORS.

By GEORGE S. DERBY, M. D., Boston, Mass.

Benign Epibulbar Tumors and Their Treatment—Polypus—Granuloma—Lymphoma—Hard and Soft Fibroma—Hemangioma—Lymphangioma—Angioma — Dermoid Tumors — Lipoma — Dermolipoma — Nevus — Papilloma — Malignant Epibulbar Growths and Their Surgical Treatment—Sarcoma—Extirpation of Epibulbar Sarcoma—Epithelioma—Carcinoma.

Epibulbar tumors may be designated as those growths which arise from the anterior hemisphere of the globe, comprising the cornea, as well as the sclera and its conjunctival covering. They may broadly be divided into two classes, *benign* and *malignant*.

BENIGN EPIBULBAR TUMORS.

Cysts.

In the first class we may mention the cysts which occur in this region and divide them into *traumatic,* which occur as the result of injury, especially in tenotomy wounds and around foreign bodies; *lymphatic* cysts, from dilatation of the lymph spaces; *pseudo-cysts,* which may develop from symblepharon or from a subconjunctival hemorrhage; finally, *congenital* cysts, occurring with congenital tumors or associated with microphthalmia.

When cysts growing in the conjunctival sac give rise to discomfort or cause irritation, their removal is indicated. This is best accomplished by, first, puncturing the growth with a sharp knife, and then removing a portion of the anterior wall with forceps and scissors. The inner surface of that portion of the cyst wall which remains should be thoroughly curetted, and, if necessary, the cavity swabbed out with tincture of iodine.

Polypus.

According to Elschnig,[1] true polypus of the conjunctiva is un-

[1]Elschnig. On the Polypoid Tumors of the Conjunctiva. *Archives of Ophthal.*, 1889, Vol. XVIII, p. 255.

known, but, as a result of the movement of the lids and eyes, all tumors of the conjunctiva tend to become polypoid in form. Those epibulbar growths simulating polypi are usually true papillomata, soft or hard fibromata, granulomata, though even dermoids or sarcomata may assume this shape (Parsons[2]).

Granuloma.

This neoplasm occurs not infrequently as the result of ulceration and injury. It is not uncommon in incompletely closed tenotomy wounds, and may grow to a large size.

The growth should be excised close to its base with scissors and forceps. After bleeding has ceased, the base may be touched with some cauterant, such as the solid stick of silver nitrate, great care being taken that its action be confined to the base of the growth.

Lymphoma.

Epibulbar lymphoma is a rare tumor, and its treatment is seldom, if ever, surgical.

Hard and Soft Fibroma.

These growths affect the bulbar conjunctiva less frequently than the conjunctiva of the lids. If they cause irritation their removal with scissors and forceps may be carried out very simply. The growth is snipped off close to its base, which need not be cauterized. With the soft variety Saemisch[3] advises first placing a ligature, as profuse hemorrhage may follow the excision.

Hemangioma. Lymphangioma.

The first of these may be either capillary or cavernous in structure; while *lymphangioma* may be divided into *lymphangiectasis* (which consists of minute dilatations of the lymphatics) and true lymphangioma, that may attain a considerable size.

The *angioma* is a benign tumor in that after a thorough removal it does not recur or form metastases. It should, however, when it shows an increase in size, be removed. On account of the danger of hemorrhage, Saemisch[4] advises that the growth should be first tied off, which is accomplished, as Fehr points out, by passing a straight needle with a double suture through the middle of the base of the tumor, and then cutting the suture at the needle and tying one thread around the base of the upper half, while the other thread is employed for the lower half. The growth is then seized with toothed forceps and snipped off, close to its base, with scissors. Great care should be taken to remove

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[2]Parsons. *Pathology of the Eye*, Vol. I, pp. 119 to 146.

[3]Saemisch. Krankheiten der Conjunctiva. *Handbuch der ges. Augenheilk.*, 2nd Edition, Vol. V, Pt. 1, p. 668.

[4]Saemisch. *Loc. cit.*, p. 661.

all the tumor tissue thoroughly, and it is safer to cauterize the base with the actual cautery. With the lymphangioma, less thorough methods will answer.

Dermoid Tumors.

Operation may be desired for cosmetic reasons or because of the irritation produced by the growth. The tumor is seized with toothed forceps and its corneal portion dissected with a cataract knife down to the level of the surrounding cornea. No attempt should be made to dissect the growth down to transparent corneal tissue, since it commonly reaches into the deepest corneal layers, and an attempt at such thorough removal may result in perforation. It is then dissected back to the limbus with the knife, and the remaining portion excised with scissors. The surrounding conjunctiva may be undermined and drawn over the scleral defect with one or two sutures.

Lipoma. Dermolipoma.

In regard to the operative treatment of lipoma and dermolipoma, one point is worthy of mention. In removing fatty subconjunctival growths, it is best not to follow them beyond the folds of transmission, but to leave the deeper parts unmolested, being careful to see that none of the orbital fat is removed with the growth.

Nevus.

Although nevus is essentially a benign growth it possesses a marked capacity for becoming malignant. Its usual seat is the limbus. When it shows the slightest signs of enlarging or becoming progressive, it should be removed. Care should be taken to leave no remnants, and especial precautions should be exercised in removing that portion of the growth which is intimately adherent to the limbus. Here a thin layer of healthy tissue may also be excised, and, as a further precaution, the site should be cauterized.

Papilloma.

According to Saemisch[5], papilloma occurs frequently at the limbus; less often on the bulbar conjunctiva. There can be no doubt that at times it becomes malignant, and undergoes carcinomatous degeneration. For that reason, it should be removed as soon as it occurs, and as it is very prone to recur, the base of the growth should be curetted and, when possible, the actual cautery used.

MALIGNANT EPIBULBAR GROWTHS AND THEIR SURGICAL TREATMENT.

In this division there are but two growths to which we need pay attention, *epibulbar sarcoma* and *carcinoma,* or rather *epithelioma.*

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[5]Saemisch. *Loc. cit.*, p. 669.

Sarcoma.

The seat of this growth is usually the conjunctiva immediately adjacent to or at the limbus. The base is, in most cases, small, even though the tumor itself be of considerable size. Opinion as to its malignancy and proneness to recur varies considerably. The general view is well summed up by Strouse[6] who concludes, after giving the statistics of 24 cases, that sarcoma of the limbus never invades the eyeball, that metastases practically never occur, that recurrences are frequent but do not contraindicate conservative measures of treatment. Radical pro-cases in which the growth has attained extensive proportions or in which vision has been destroyed.

Strouse's statistics are, however, incomplete. Nine of his cases came to enucleation or exenteration, and only one case apparently was observed over two years without recurrence being noted.

These opinions, however, fairly well represent the attitude of the majority of writers, especially to within a few years, although notable exceptions occur.

Berry[7] says, "When, therefore, no doubt exists as to their nature, the best treatment, unless the other eye should be blind or absent, is to remove the eye, and at the same time a part or all the contents of the orbit."

With Berry on the side of radical treatment stand Verhoeff and Loring[8] with the most complete statistics that have yet been published.

Total primary abcissions		53
No recurrence:		
After six months' observation	1	
After one year's observation	4	
After two years' observation	1	
After several years' observation	2	8
Recurrences:		
Within one year	10	
Within two years	3	
Within several years	4	
Exact time not stated	19	36
Not followed after operation		9
		53

[6]Strouse. Sarcoma of the Corneal Limbus. *Archives of Ophthalm.*, Vol. XXVI, 1897, p. 217.

[7]Berry. *Diseases of the Eye.* Phila., 1889, p. 59.

[8]Verhoeff and Loring. A Case of Primary Epibulbar Sarcoma, with Secondary Growths in Limbus and Sclera, and Invasion of the Choroid, Ciliary Body and Iris. *Archives of Ophthalm.*, Vol. 32, 1903, p. 97.

Their conclusions from these statistics are as follows:

1. "Epibulbar sarcoma differs from general sarcoma in malignancy only insofar as it is isolated on the highly resistant cornea and sclera, and comes to operation relatively small.

2. While highly malignant, it seldom penetrates the eye.

3. After abscission the tumor sooner or later usually recurs and general metastases are not infrequent.

4. A microscopic examination having made the diagnosis certain, immediate enucleation should be advised in all cases, but the final choice of operation must lie with the patient to whom the highly unfavorable prognosis has been made clear."

Parsons[9] is also inclined to believe that general opinion on this subject is wrong and that these growths should be treated by primary enucleation.

The exact situation (with the unfavorable results of local operation) should be stated in the clearest possible terms to the patient and he should be advised to have the eye out. If, however, the growth is small and enucleation is refused, local removal may be carried out providing the patient agrees to remain under careful surveillance, so that a recurrence may be watched for and recognized in the shortest possible time after it occurs. In those persons who cannot or will not remain under observation, enucleation should be insisted upon, always assuming that the other eye is a serviceable one. In case it is not, it goes without saying that every attempt must be made at thorough local removal of the growth.

Extirpation of Epibulbar Sarcoma.

The conjunctiva should be incised with scissors at a distance of 3 to 4 mm. around the growth. The tumor itself should be excised with a Graefe knife or very sharp, small scalpel, an attempt being made to go deep enough into the cornea and sclera to include a layer of healthy tissue. The growth should be handled and lacerated as little as possible to avoid the dissemination of tumor cells throughout the field of operation. Finally, the operative area should be burnt thoroughly with the cautery at a dull red heat. In case the growth appears to be very vascular, the base should be tied off before operation.

Epithelioma.

Like sarcoma, epithelioma occurs by preference at the limbus and more often at the outer side. Even if of considerable size, its attachment to the globe may be limited to a comparatively small area. It is more likely to spread laterally as a flat growth than to project forward from the globe. It usually infiltrates extensively the *substantia propria*

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[9]Parsons. *Loc. cit.*, p. 140.

of the cornea and sclera, although it may not penetrate beneath Bowman's membrane. The epibulbar epithelioma is far oftener implanted from a growth in the lid than it is of primary origin. Penetration into the interior of the eyeball is rare, but this excursion occurs more frequently than in the case of sarcoma, while involvement of the neighboring glands occurs relatively seldom.

Epithelioma of this region differs microscopically but little from that of other parts. Parsons states that its malignancy varies irrespective of the microscopic picture, but on this point there is a difference of opinion. Certain it is that its growth follows no set rule. For a long time it may show little if any change in volume; then it suddenly begins to grow with extraordinary vigor, apparently as the result of a trauma or of some irritating treatment. The incomplete removal of the growth, or its cauterization may be followed by a recurrence which shows much more active signs of growth than did the original tumor.

The dangers of metastasis being considerably less than in epibulbar sarcoma, a less radical form of treatment is indicated. In suitable cases, i. e., when the tumor is small and circumscribed, its rate of growth slow, and when the deeper layers of the cornea and sclera are not infiltrated extreme measures are not called for. In those cases however, in which a large nodule rapidly increasing in size exists and when the vision is permanently impaired, enucleation should be advised, always supposing that the patient's unaffected eye is serviceable.

For the removal of *epibulbar carcinoma,* the reader is referred to the operation for sarcoma.

CHAPTER III.

OPERATIONS ON THE EXTRINSIC OR ORBITAL MUSCLES.

By EDWARD JACKSON, A. M., M. D., Denver, Colo.

Surgical Anatomy and Physiology—General Arrangement and Actions—Wide Tendons of Insertion—Actions in Different Positions of Eyeball—Primary and Secondary Functions—Contact Arcs—Dimensions of the Muscles——Connective Tissue Structures of the Orbit—Check Ligaments—Vascular and Nervous Supply—Historical Review—Classification of Operations—Condition of the Patient—Position for Operation—Anesthesia and Hemostasis—Instruments Required—Tenotomy by the Open Method—Complications—Effect of Tenotomy of Internus—Sequels and After treatment—Variations in Open Tenotomy — Subconjunctival Tenotomy — Tenotomy of Externus—Effects of Tenotomy of Externus—Tenotomy of Superior and Inferior Muscles—Tenotomy of More than One Rectus—Extension of Tenotomy—Tenotomy Extended to Secondary Adductors—Danger of Exophthalmos—Extension to the Capsule of Tenon—Thread Operations to Increase the Effect of Tenotomy—Partial Tenotomy—Elongations of Tendons by Division and Suture—Tenotomy of Inferior Oblique—Tenotomy of Superior Oblique—Advancement Operations—Advancement of Muscle with Capsule—Advancement of All Tissues with Scleral Stitch—Advancement with Partial Isolation of Tendon—Advancement with Anchor Stitch—Advancement with Slitting of the Tendon—Special Forms of Suture for Muscular Advancement—Advancement with Folding of the Tendon—Tendon Folding with Triple Hook—Advancement with Tendon Tuckers—Use of Tendon Clamp—Shortening Muscle with Section or Resection—General Considerations Regarding Advancement Operations—Operations to Enable One Muscle to Take up the Functions of Another—Transplantation of Superior Rectus—Change of Direction of Line of Insertion of Rectus Tendon—Transplantation of Temporal Half of Superior and Inferior Recti—Transplantation for Oculo-motor Paralysis—Miscellaneous Operations to Influence the Positions of the Eyeball—Passive Motion—Stretching of Tendon and Connective Tissues—Check Ligaments—Exsection of Tendons—Exsection of Capsular Tissues—Advancement of Capsule—Partial Fixation of Globe—General Indications—Effects to Be Aimed at in Operation—Choice of Operation to Be Performed—Choice of Operation in Comitant Strabismus—Choice of Operation for Paralytic Strabismus—Caution.

Surgical Anatomy and Physiology.

The operations described in this chapter are done to modify the actions of the muscles, which arise from the bony wall of the orbit,

and are inserted into the sclerotic coat of the eyeball. A clear understanding of the functions performed by and through these muscles must accompany a knowledge of the surgical anatomy of the parts as a basis for any proper understanding of these operations.

General Arrangement and Actions.

These muscles are six in number, arranged in pairs. For certain positions of the eye, and for certain movements, the two muscles of each pair are antagonists. For other positions of the eye and other movements they act together. Their general relations to the eyeball and surrounding parts are shown in Plate V. and Fig. 284.

Four of these muscles, the recti, arise from practically a common origin around the optic foramen at the apex of the orbit, pass from this point directly to about the equator of the eyeball, and curve around in contact with the sclera to be inserted in its anterior hemisphere. The other two muscles, the obliques, both act as from an origin near the anterior margin of the orbit, passing outwards and backwards to the eyeball and curving around it to be inserted in the posterior one-third of the sclera. The four recti, acting together, tend to draw the eye back into the orbit—to retract it. The two obliques, acting together, tend rather to draw the eyeball forward—to cause it to protrude. All these six muscles, acting from the nasal side of the orbit, would, if unopposed, draw the eyeball against the lateral plate of the ethmoid. Each rectus being inserted upon the eyeball in front of the center of rotation, tends to turn the *anterior pole* of the eye, the cornea, towards its insertion. Each oblique, inserted behind the center of rotation, tends to turn the *posterior pole* of the eye towards its insertion; and the anterior pole or cornea, in the opposite direction.

Wide Tendons of Insertion.

Each of these muscles is inserted into the sclera by a tendon that is very broad, as compared with the length of the muscle. The greatest diameter of the insertion of the biceps is about 1/18 of the total length of the muscle and its tendon, and only ¼ or ⅓ of the maximum diameter of the belly of the muscle. But the breadth of the insertion of the internal rectus is ¼ of the length of the muscle, and 1.3 times the maximum diameter of the muscular belly. The insertion of the inferior oblique is about 10 mm. wide, one-half the total length of this muscle and its tendon, and the same proportion holds between the insertion of the superior oblique, and its distance from the pulley from which, in effect, it acts. Although for certain purposes it is convenient to think of one of the ocular muscles as inserted at a certain point, and acting as a whole upon that point of the sclera, it must not be forgotten that different portions of the muscle are inserted at

widely different points, and capable of producing correspondingly different movements of the eyeball.

With a globe like the eyeball the rotation produced by a certain force acting tangent to its surface depends both on the direction of the force, and the location of the point to which it is applied. Trac-

Fig. 284.

Muscles of Orbit as Viewed from Above and Behind.

a Internal rectus muscle.
b External rectus muscle.
c Superior rectus muscle.
d Elevator of the upper lid (severed).
e Superior oblique muscle.
f Pulley of superior oblique.
g Superior oblique tendon.
h Inferior oblique muscle (insertion).
i Eyeball.
j Lachrymal gland.
k Orbital fat.
l Optic nerve.

tion towards the apex of the orbit, if applied at the top of the eyeball, above the center of rotation, will tend to turn the cornea up. A force acting toward the same point, but applied below the center of rotation will tend to rotate the eye in just the opposite direction, to turn the cornea down. All the fibres of the internal rectus muscle, being inserted to the nasal side of the cornea, tend by their contraction, to turn the eye inward. But the upper fibres, inserted higher than the center of rotation, tend to turn the cornea upward; while the lower fibres, inserted lower than the center of rotation, tend to turn the cornea downward. It is probable that such relatively antagonistic actions on the part of the extreme fibres of the same muscle have an important influence in securing steadiness of the delicate ocular movements. This influence is the greater because of still broader connections of these tendons, the muscle being practically also inserted

Fig. 285.
Diagram Showing Influence of Internal Rectus Muscle on Vertical Movements; when the Eye is Turned Up Helping to Turn it Up.

into the capsule of Tenon by the lateral fibres, making the tendon continuous with adjoining connective tissue. These important relations must all be borne in mind when making an operative mutiiation of the parts.

Different Actions in Different Positions of the Eyeball.

But not only do different fibres of the same muscle tend to produce different rotations of the eyeball. The contraction of the same muscle fibres may produce totally different effects, when the eyeball has been placed in different positions. Take, for instance, the central fibres of the internal rectus muscle. When the line of sight is about level, and the horizontal plane passing through these fibres, passes through the center of rotation of the eye, their contraction tends to turn the eye in, but neither up nor down. But if the eye be turned

upward, say 40 degrees, the relation of the plane of muscular action to the center of rotation is changed, as indicated in Fig. 285.

These fibres no longer tend simply to turn the eye in, they also tend to turn it up. Again, if the eye is already turned downward 40 degrees the contraction of these same fibres will tend to turn it farther down, as shown in Fig. 286.

Primary and Secondary Functions.

In all positions of the eye contraction of the internal rectus muscle tends to turn the eye in. This may be called its primary function. In certain positions the same contractions assist in turning the eye up or down; these may be called secondary functions or actions of the muscle. Each of the six muscles under consideration has primary and secondary actions. The secondary actions of the external rectus

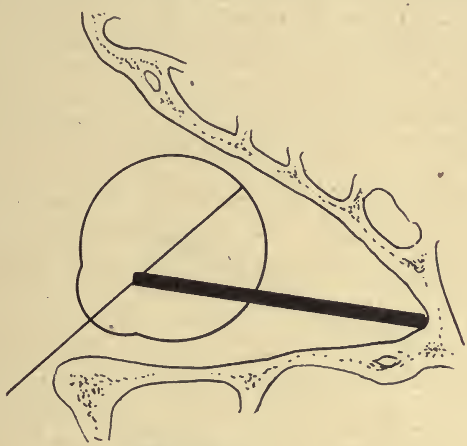

Fig. 286.

Action of Internal Rectus Muscle, when the Eye is Turned Down Helping to Turn it Down.

are practically the same as those of the internal rectus and can be understood from the same diagrams.

The superior and inferior recti muscles arising about the optic foramen pass forward and outward, their general direction making an angle of about 26 degrees with the visual axis and median plane of the head, as shown in Fig. 287.

With the eyes in the primary position the superior rectus not only tends to turn the cornea up, but also in. The superior and inferior recti acting together become important adductors. Their adductive influence increases as the eyes converge. With the eyeball turned to the temporal side, so that the visual line makes an angle of 26 degrees with the median plane of the head, the central fibres of the superior rectus tend simply to roll the eyeball up; and the contraction of the

central fibres of the inferior rectus simply tends to turn the cornea down. See Fig. 288.

If the eye be turned still farther toward the temporal side, these central fibres of the superior and inferior recti muscles begin to assist in turning it out. This abductive effect increases the more the eye is turned out, reaching a maximum in cases of extreme divergent strabismus. See Fig. 289.

However, for the superior and inferior recti the adductive influence is generally much more important than the abductive; they may be termed secondary adductors of the eyeball. Their effect reaches a maximum when the eye is turned strongly in, as it is in high degrees of convergent squint. See Fig. 290.

The superior and inferior recti, aiding the internal rectus, would overpower the external rectus, were it not assisted by secondary abductors—the superior and inferior obliques.

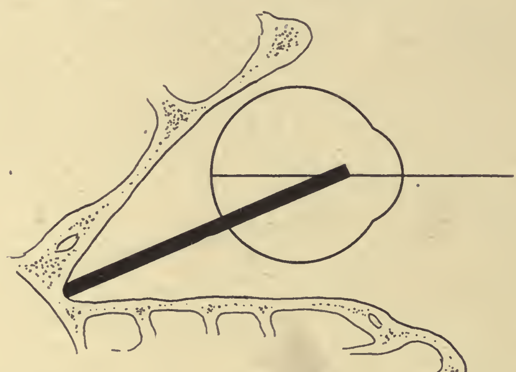

Fig. 287.

Diagram Showing the Angle which the Direction of the Central Fibres of the Superior Rectus or the Inferior Rectus makes with the Median Plane of the Head, or with the Direction of the Visual Axis when the eyes are in the Primary Position.

The superior oblique passing backward and outward from its pulley to the posterior half of the sclera makes an angle of about 40 degrees with the median plane of the head. The inferior oblique, arising from the wall of the orbit just within the lower nasal margin, passes outward and backward at about the same angle. Acting upon the eyeball back of the center of rotation together, the obliques tend to turn the posterior pole in, and the cornea out. Their function as secondary abductors of the eyeball is an extremely important one.

Their abductive effect is at a maximum when the axis around which they tend to rotate the eye is perpendicular to the direction of their action; that is, when the eye is turned out about 50 degrees. From this position either way their abductive effect diminishes. If

the eye were turned in, to the direction in which the obliques act, so that the visual axis made an angle of 40 degrees with the median plane of the head, the obliques would cease to act as abductors; and if

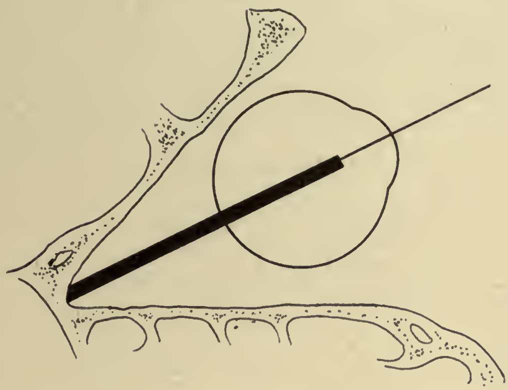

Fig. 288.

Eye Turned 26 Degrees Toward the Temporal Side. The Superior or Inferior Rectus Tends to Turn the Eye Directly Upward or Downward.

the eye were turned a little farther in they would begin to act as adductors.

We may take the primary function of the obliques as *torsion* of

Fig. 289.

Eye Turned More than 26 Degrees Toward the Temporal Side. The Superior or Inferior Rectus Tends to Turn the Eye Out.

the eye, or rotation about the visual axes. Contraction of the superior oblique producing *intorsion;* contraction of the inferior oblique producing *extorsion.* A secondary action of the superior oblique is

to turn the cornea down. The maximum effect of this kind is produced when the eye is turned in; and no such effect results from its contraction when the eye is turned out 50 degrees. Contraction of the inferior oblique tends to turn the cornea up when the eye is

Fig. 290.

Eye Turned Strongly in. The Superior and Inferior Recti Muscles Act as Adductors.

turned in, but this secondary function is lost when the eye is turned out 50 degrees.

In operating upon one or more of the eye muscles, to

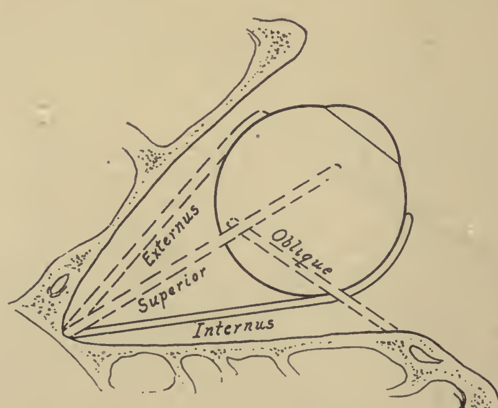

Fig. 291.

Diagram Showing the Actions of the Different Extrinsic Ocular Muscles when the Eye is Turned Strongly Outward. The Internus Alone Acts as an Adductor. All the Others Act as Abductors.

change their relations to the globe and their influence upon its rotations, we should carefully consider the effects likely to be produced

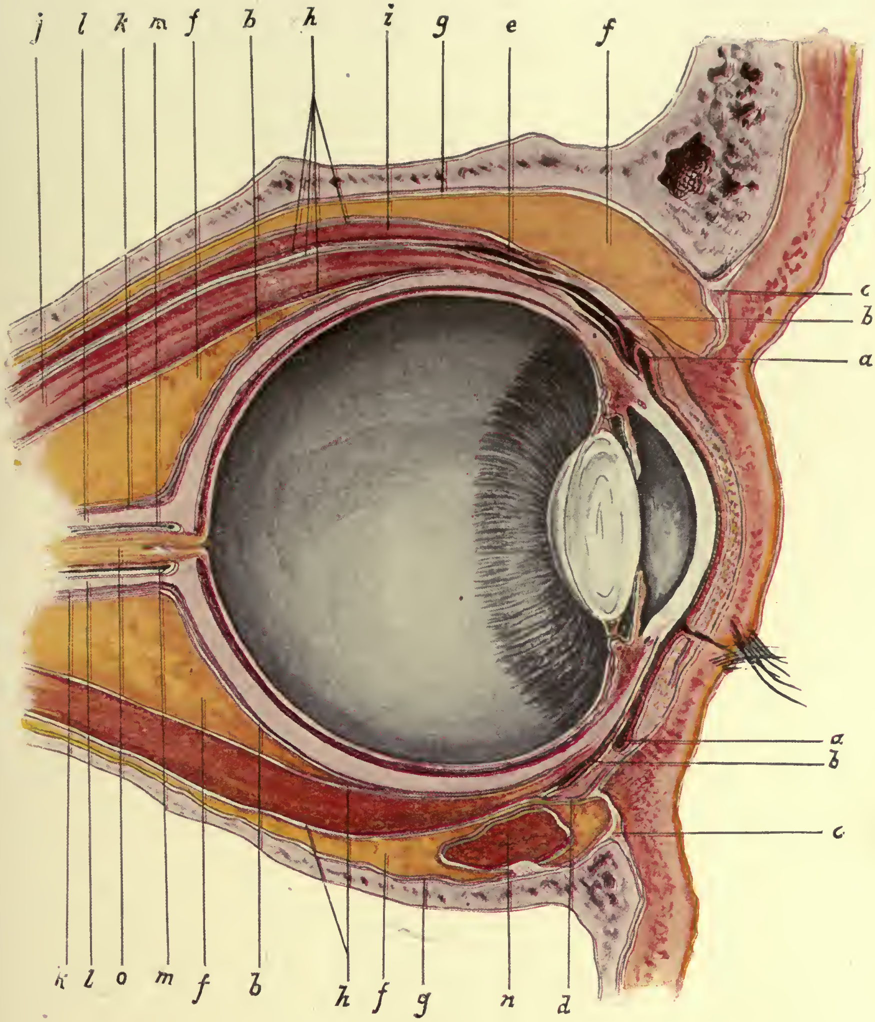

PLATE V

Orbital Fascia and Capsule of Tenon. Vertical Section in Line of the Optical Nerve.

a. Conjunctival fornix.
b, Capsule of Tenon.
c. Orbital septum or orbito-tarsal ligament.
d. Check ligament of inferior rectus.
e. Connection between superior rectus muscle and levator palpebræ superioris muscle.
f. Fat.
g. Periosteum of orbit.
h. Orbital fascia
i. Levator palpebræ superioris muscle.
j. Superior rectus muscle.
k Supravaginal lymph space.
l. Fibrous sheath of optic nerve.
m. Intervaginal lymph space.
n. Inferior oblique muscle.
o. Optic nerve.

upon their secondary actions as well as the change aimed at in the primary function.

Contact Arcs.

The maximum effect of a muscular contraction upon the direction of the eyeball is produced when the force is exerted in a direction tangent to the surface of the globe. To secure this maximum effect in all ordinary positions of the eye, the tendon of insertion of each of these muscles curves around the eyeball in contact with the sclera for some distance, before being inserted into the sclera. These "contact arcs" permit considerable movement of the eyes, without sacrificing the advantage of having the muscular force exerted tangent to the surface of the eyeball. Figures 292 and 293 illustrate the contact arcs of the internal and external recti muscles in different positions of the

Fig. 292.
Diagram Showing Contact Arcs of the External and Internal Recti Muscles when the Eye is Turned Outward.

eye. If the eye be turned directly forward the contact arc of the internal rectus is about 5 mm. (about 25 degrees). If turned out (Fig. 292) it is greater. In the primary position the contact arc of the external rectus is 13 mm. (about 65 degrees).

If the eye is made to turn in more than 25 degrees the contact arc of the internal rectus is unwound from the eyeball so that the muscle no longer acts in a direction tangent to the surface of the globe. On the other hand the eye can turn out to the maximum extent 55 degrees, and still retain a contact arc of 2 mm., corresponding to additional rotation of 10 degrees.

If the insertion of a tendon is permitted to slip back by tenotomy, the contact arc is to that extent shortened. On the other hand bringing forward the insertion of a tendon will lengthen the contact arc.

The binding down of the tendon to the sclera by cicatricial tissue, where this follows either tenotomy, advancement, or traumatism, diminishes to that extent the contact arc. It shortens the portion of the tendon that can be unwound from the eyeball, giving the effect of a backward displacement of the insertion.

Dimensions of the Muscles.

Taking as the apex of the orbit the temporal edge of the optic foramen, the center of the eyeball on the average, is situated 36 mm. anterior to this. This is about 4 mm. in front of a line joining the outer angles of the two orbits. The center of the ball is about 30 mm. from the median plane of the head, or 16 mm. external to the nasal

Fig. 293.

Contact Arcs of the External and Internal Recti Muscles when the Eye is Turned in.

wall of the orbit. The extreme length of each of the recti muscles with its tendon is about 40 to 45 mm. The width of their insertions and the distance of the center of each insertion from the margin of the cornea, according to Howe[1] and the length of the tendon of insertion, according to Fuchs,[2] are as follows:

	Int. Rectus.	Inf. Rectus.	Ex. Rectus.	Sup. Rectus.
Width of insertion	10.3	9.9	9.2	10.6
Distance from cornea	5.7	6.7	7.4	7.6
Length of tendon	8.8	5.5	8.7	5.8

These insertions are usually convex toward the cornea, so that the end of each insertion, the insertion of the edge of the muscle, is distinctly farther back from the cornea than the figures given. There are

[1]Howe. *The Muscles of the Eye*, Vol. I., p. 34.
[2]Fuchs. *Archiv für Ophthal.*, XXX., Pt. 1.

also considerable variations in individual cases so that the position of the insertion may vary from 5 mm. or even less, for the internus, to 12 mm. back from the cornea for the temporal margin of the superior rectus. The insertion may also depart from a straight or regularly curved line some portions of it being irregularly thrown forward or behind other parts.

In normal eyes the insertion of the lateral recti may often be recognized through the conjunctiva and subconjunctival tissues. For the superior and inferior recti this is not often possible. But after a tenotomy the sclera exposed by slipping back of the tendon is commonly noticeable on close examination. The insertion of these tendons may present further anomalies. Slips are sometimes given off from the edges of the tendons to be attached beyond the usual lateral limits of the insertion; or from the surface of the tendon in contact with the

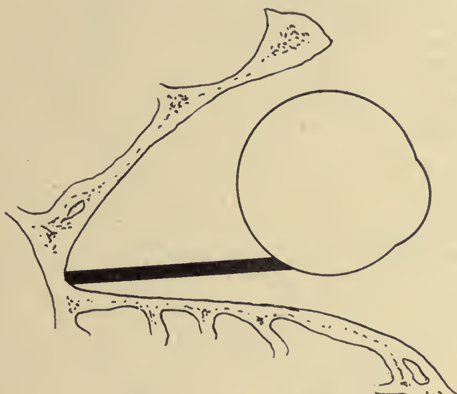

Fig. 294.
Diagram Showing Loss of Contact Arc from Tenotomy.

eyeball, to be inserted into the sclera farther back than the main insertion. In all cases connective tissue extends from the muscle sheaths and tendons, to fuse with other connective tissue structures of the orbit, especially with the so-called capsule of Tenon. These additional connections vary widely and in some cases may be of practical importance.

The superior oblique muscle, passing from its origin forward along the inner wall of the orbit, has a length of about 40 mm. before it reaches the pulley. From the pulley to its insertion on the eyeball its length is from 15 to 20 mm. At the pulley the tendon is not more than 3 or 4 mm. in diameter. But it spreads out into a fan-shaped membrane; so that its insertion, chiefly in the upper posterior temporal quadrant of the globe is, in some cases, more than 15 mm. across; although sometimes its breadth has been set down as 7 mm. or

less. The inferior oblique arises from a depression in the orbital plate of the superior maxilla; just within the lower margin of the orbit, and just to the temporal side of the nasal bone. This is the point at which the muscle is most superficial, the point of selection for operative interference. Passing back and to the temporal side, just beneath the inferior rectus, it is inserted in the outer, posterior, lower quadrant of the sclera. The breadth of the tendon at the line of insertion varies from 7 to 12 mm. The lines of insertion of both obliques vary markedly in form and position, and their tendons fuse with the adjoining connective tissue structures even more completely than do those of the recti. On these accounts, as well as because of their deep situation, operative interference near their insertions into the sclera is not practicable.

Of the other muscles of the orbit the elevator of the upper lid is

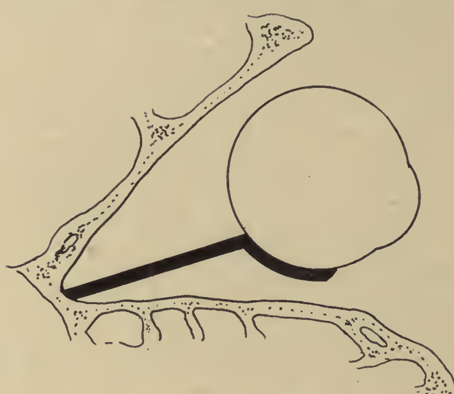

Fig. 295.

Practical Loss of Contact Arc by Adhesion of Tendon to Sclera Back from the Normal Insertion.

fully considered in Wilder's chapter. The involuntary muscles are also concerned with the retraction of the lids, and are not subjected to operation. The anomalous slip, known as the transversalis, comes off from the elevator, and is to be considered with that muscle. The tensor tarsi, Horner's muscle, is thought by Howe to be concerned in the sinking of the caruncle that follows some tenotomies. It arises from the lachrymal bone behind the lachrymal sac; and passes outward dividing into two parts, one of which lies behind each canaliculus to be inserted into the tissue of the two lids. It is commonly classed with the lid muscles, and supposed to influence the removal of the tears.

Connective Tissue Structures of the Orbit.

The orbit is occupied by connective tissue, in which the orbital

fat, the muscles, eyeball, ocular vessels and nerves are embedded. This connective tissue is in some parts extremely loose and non-resistant. Other parts are condensed into membranes and ligaments calculated to resist considerable force. These membranes and ligaments are conveniently mentioned and described under special names. But we should bear in mind that they are continuous with the looser, unspecialized, orbital connective tissue.

The more important membranous condensations of the orbital

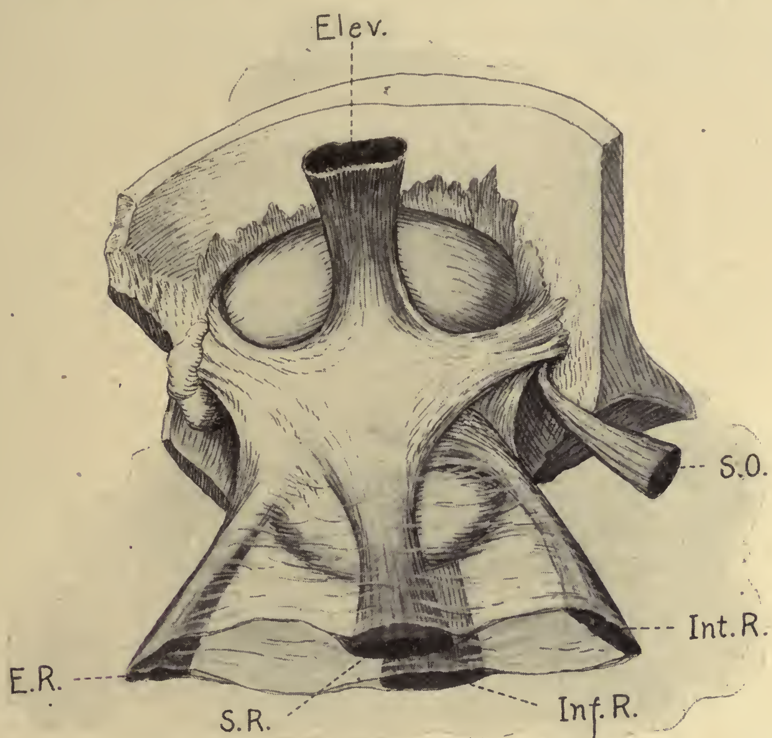

Fig. 296.

Relations of the Extrinsic Ocular Muscles to the Connective Tissue Structures of the Orbit as Viewed from Above and Behind (after Motais). Note the lateral expansion of the tendons and the delicate membranous connections of the muscle sheaths. Elev. Elevator of upper lid. E. R. External rectus. S. R. Superior rectus. Inf. R. Inferior rectus. Int. R. Internal rectus. S. O. Superior oblique.

connective tissue constitute the so-called *capsule of Tenon*. Its general arrangement within the orbit is shown in Plate V.

The membranes which stretch from the margins of each of the recti muscles become especially thickened anteriorly, and spreading out from the muscle sheath and tendon constitute the "little wings"

or "fins" ("ailerons") of Motais,[2a] which are generally called the *check ligaments.* Still farther forward the connective tissue condensation forms a membrane enclosing the posterior portion of the globe and reflected to extend to the margins of the orbit, the orbito-ocular fascia. This is the part of the capsule of Tenon to be dealt with in ocular muscle operations. This portion is shown in Fig. 297, representing a vertical antero-posterior section of the orbit.

The membrane covering the eyeball at the insertion of the muscles is comparatively thin and little noticeable. But it is sufficient to offer a serious obstacle to the introduction of the strabismus hook, if this is attempted without an opening having been made in it. The

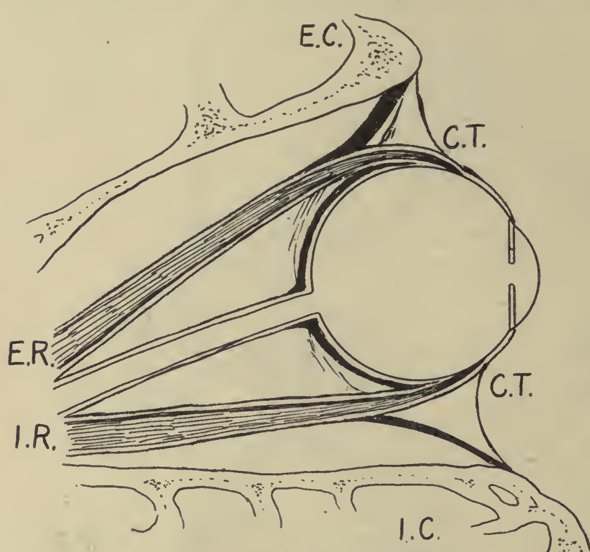

Fig. 297.

Condensations of Orbital Connective Tissue Shown in Black. Diagram of horizontal section. E. C. External check ligament. C. T. Capsule of Tenon where it is most disturbed in muscle operations. I. C. Internal check ligament. E. R. Externus rectus muscle. I. R. Internal rectus muscle.

deeper thickenings which stretch from behind the eyeball to the margin of the orbit furnish a very important support which holds the eyeball in proper position against the conjoined actions of the ocular muscles. It constitutes a sort of hammock in which the ocular globe is turned and swung, in obedience to the various motor impulses applied by the straight and oblique muscles. Damage to this supporting structure is chiefly responsible for the displacements of the eye that have followed reckless operating for strabismus. While the ocular

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[2a]Motais. Ailerons ligamenteux. *Anatomic de l' Appareil Moteur de l'Oeil de l'Homme et des Vertébrés*, p. 86.

muscles have their main insertions into the sclera and act chiefly upon it, they have minor attachments to the structures surrounding the eyeball, so that each movement of the ocular globe is normally accompanied by a certain amount of movement in surrounding parts.

Check Ligaments.

The curtain of condensed connective tissue that stretches from the eyeball to the margins of the orbit, part of the so-called capsule of

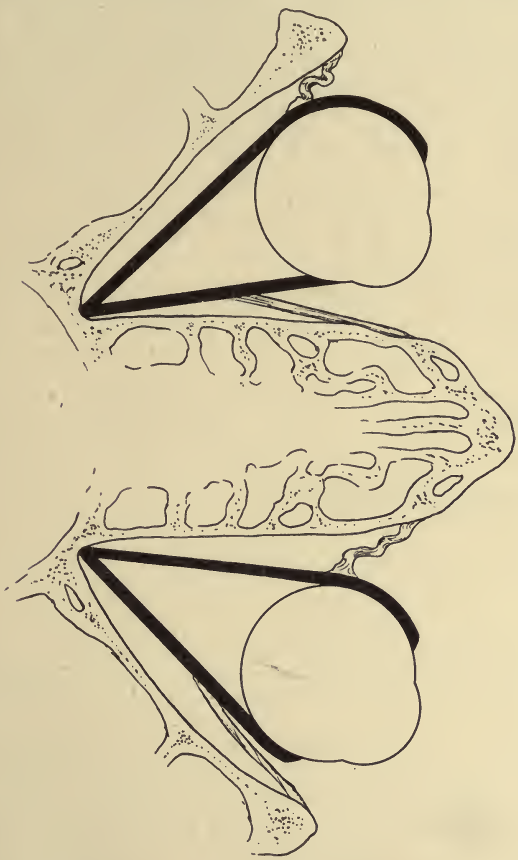

Fig. 298.

Diagram Showing Tension and Relaxation of the Lateral Check Ligaments, when the Eyes are Turned Strongly to the Right. The ligaments connected with the right externus and left internus are tense. Those connected with the right internus and left externus are relaxed.

Tenon, appears to be distinctly thickened opposite the four recti muscles. Although these thickenings are not sharply limited and vary considerably in extent, thickness, tension, and relations with the neighboring structures, it is convenient to recognize them under the name of

check ligaments. As described by Motais, they arise from the orbital surface of each muscle, passing forward to be inserted in the orbital margin. Their relations are also illustrated in Fig. 298.

The check ligament constitutes a sort of supplementary tendon of insertion for the muscle, which, however, is so relaxed under ordinary conditions that none of the muscular force is exerted through it. If, however, the muscle is very strongly contracted, as the external muscle of the right eye is represented to be in Fig. 298, the check ligament may be put upon the stretch so that the muscle can no longer exert much force to rotate the eyeball, the movement of which is thus limited by the ligament. Backward displacement of the muscle insertion, as by tenotomy, also tends to put the check ligament on the stretch, and thus the movement of the eyeball in that particular di-

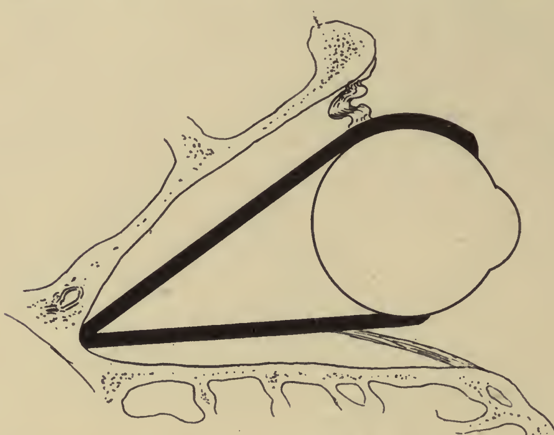

Fig. 299.

Diagram Showing Influence of Tenotomy and Advancement on the Check Ligaments. The internus having been tenotomized its check ligament is put upon the stretch. The externus having been advanced its ligament is relaxed.

rection is still more narrowly limited. Such a condition following tenotomy of the internal rectus is indicated in Fig. 299. On the other hand the advancement, shortening or tucking of a tendon tends to bring forward the muscular origin of its check ligament, relaxing it more than the normal, and removing its power to check the rotation of the globe.

Vascular and Nervous Supply.

The arteries and venous branches, which supply the parts involved in these operations are not sufficiently constant to need discussion in this connection. The larger veins are always visible. They occasion the most troublesome bleeding. Often the necessary incisions, especially that in the conjunctiva, may be so placed as to avoid them.

Or the necessary division of a large vein may be deferred until it will cause the least annoyance and delay. The motor nerves of the ocular muscles enter the muscles so far back as to be outside the field of operation. The sensory nerves are branches of the first division of the fifth cranial nerve. In a general way they pass from the nasal toward the temporal side of the orbit, but the trunks are not sufficiently superficial and constant to render practicable anesthesia by injections of anesthetic solutions in their immediate neighborhood.

Historical Review.

The malposition of the eyes which constitutes strabismus, either as a temporary condition associated with convulsive seizures, or permanent in certain individuals, has been recognized from the earliest period of medical history. But not even the anatomy of the muscles concerned in ocular movements was understood with approximate accuracy until studied by Fallopius in the 16th century. After this the absence of perceptible pathologic changes in the muscles, even with strabismus of long standing, and the temporary character of some squints that were not differentiated from the permanent deviations, tended to discourage attempts to relieve the deformity by resort to operative procedure.

In the middle of the 18th century, John Taylor claimed to straighten cross-eyes by operation. He was born in Norwich, England, in 1703 or 1708, the son of a mathematician, was well educated and skillful, and a pupil of Cheselden. He published his first work, *"An Account of the Mechanism of the Eye"* in 1727. Amplified editions of this work were published in Spanish in 1732, in French in 1737, and in German in 1750. He could claim medical degrees granted in Basel, 1734, in Liege, 1735, Cologne, 1735, and Coimbra, 1738. He was the author of other writings. But what sort of operation he performed for strabismus is not described in his published writings; and with regard to this operation his behavior was clearly that of a charlatan. His explanations of what he did were not frank or satisfactory. He claimed at one time to cure convergent strabismus by division of the superior oblique. But he explained to LeCat that he divided one of the nerve filaments passing to the too powerful internal rectus muscle.

His procedure is thus described by LeCat:[3] "With a needle threaded with silk he caught a portion of the conjunctiva of the squinting eye at the inferior part of the globe, and having made a loop of the silk he used it to draw toward him that portion of the conjunctiva which it included, which he cut with the scissors; then he applied a

[3]LeCat. *Précis analytique des travaux de l'Académie des Sciences de Rouen.* t. I., p. 110 (1743).

plaster to the sound eye; the squinting eye at once righted itself and every one cried out, 'a miracle.'"

It has been suggested that his "miracle" was only the transference of the squint by covering the previously fixing eye. But as pointed out by Stevens,[4] "It is much more probable, however, that he cut the internal rectus, but that he did not confide too much in his not well-informed critics." Schroen[5] calls Taylor "the first inventor of the squint operation." Taylor lived four years in Germany, and Schroen states that he effected undoubted cures. Antonelli,[6] who has brought together the best collection of the literature on this subject, regards Taylor's claims as to the cure of strabismus, as entirely unfounded. It seems likely that he actually did cure strabismus by tenotomy of the internal rectus muscle. But evidently he never fully mastered an operation for this purpose; and during his later career he seems to have restricted his claims to other operative cures that he felt more sure of accomplishing. On account of the secrecy he observed about his procedure, and the air of mystery he tried to throw around it, he left no impression upon the general practice of his contemporaries and successors with regard to strabismus, except the mere suggestion that squint might be curable by operation.

In a study of the physiology of the ocular muscles, Sir Charles Bell, in 1823, divided the recti and oblique muscles of the eyes of lower animals; and concluded that the former had to do with the voluntary, and the latter with the involuntary movements of the eyes. In 1827 Anthony White suggested that by cutting the ocular muscles we could correct strabismus. But the suggestion was not acted on, and was forgotten until the awakening of interest in the subject by Dieffenbach's operation.

Meanwhile the treatment relied on for squint was the wearing of a mask with openings through which the eyes could see only when properly directed, as suggested by Paulus Ægineta in the 7th century; or the occlusion of the fixing eye proposed by Erasmus Darwin.[7] Clinically squint received little attention. In the text-books the account of it was very brief. It occupied one and one-half pages in Littell's *Manual* of 250 pages, and in the four volumes of von Ammon's *Zeitschrift für Ophthalmologie,* which appeared from 1830 to 1837 inclusive, strabismus is merely mentioned as a symptom two or three times. All this was changed by the discovery that it was remediable by operation.

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[4]Stevens. *Motor Apparatus of the Eyes.* Philadelphia. p. 40.

[5]Schroen, H. Die Schieloperation von ihrer Erfindung durch Dieffenbach. *Archiv. f. Ophthalmologie,* Vol. XX., p. 151.

[6]Antonelli. Un Point d'Histoire de l'Operation du Strabisme. *Archives d'Ophtalmologie,* Jan., 1902.

[7]Darwin. *Philosophical Transactions,* 1778, Vol. LXVII, Part I, p. 86.

In 1831 Stromeyer did tenotomy on the tendo-Achilles, and followed up his first partial success by operating on muscles and tendons in all parts of the body. His operation was widely adopted by surgeons throughout the world. Dieffenbach, of Berlin, claimed to have practised it on forty different muscles. Guerin, in Paris, came to be known as "Le Grande Myotomiste." In 1838 Stromeyer[8] thus described an operation which he called "myotomy for strabismus," having performed it on the cadaver. "The good eye should be closed and the patient directed to turn the affected eye away from its false position. For internal squint a fine hook may then be thrust into the ocular conjunctiva at its inner margin; and confided to an intelligent assistant, who will keep the eye turned out. The conjunctiva being raised with forceps should be divided by means of a cataract knife, making an incision near the inner canthus. The traction on the tissues is to be increased until the internal rectus appears, under which a fine probe may be passed. It is to be divided with curved scissors, or with the knife used in opening the conjunctiva."

Pauli[9] did the operation easily on the cadaver; but, attempting it on a patient, failed to fix securely the eyeball and divide the tendon. Guérin demonstrated Stromeyer's operation on the dead body, and claimed to have preceded Dieffenbach in applying it to the living patient.[10] But the era of operation upon the eye muscles may be said to begin with the announcement of Dieffenbach[11] that he had obtained a perfect result in a case of convergent strabismus by division of the internal rectus muscle.

The operation was done on the 29th of October, 1839, and is thus described:[12] "The head of the patient, a boy of 7, being fixed against the chest of one assistant, and the lids held apart by two hooks in the hands of a second assistant, thereupon I pushed a third hook through the conjunctiva at the inner angle of the eye and quite through the deep cellular tissue there, and that hook I gave to a third assistant. Then I stuck a fine little double hook into the sclerotic at the inner angle of the eye, and holding it in the left hand, drew the globe as far outward as possible. I incised the conjunctiva, close to the globe where it is spread out at the inner angle of the eye. Going deeper I dissected the cellular tissue from the ball, and then divided the muscle, with a pair of fine eye scissors, close to the globe."

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[8] Stromeyer. *Beiträge zur Operativen Orthopedie.* Hannover, 1838.
[9] Pauli. Schmidt's *Jahrbücher*, Bd. 24, p. 347.
[10] Cunier. Sur la Myotomie appliquée au traitement du Strabisme. *Annales d'Oculistique*, T. 3, Liv. 5 and 6.
[11] Dieffenbach. Ueber die Heilung des Angeborenen Schielens Mittelst Durschneidung des inneren Geraden Augenmuskels. *Medicinische Zeitsch.*, Nov. 13, 1839.
[12] Howe. *Muscles of the Eye.* Vol. II, p. 293.

This announcement by Dieffenbach, widely heralded by the lay and medical press, raised up an army of surgeons who engaged in the operative treatment of strabismus in all parts of the civilized world. Established authorities like Velpeau and Mackenzie published supplements to their text-books, describing this new triumph of surgery. Monographs and journal articles appeared in all civilized countries; the number of such writings published in 1840 to 1845, inclusive, being greater than in the thirty years that followed.

In this epidemic of squint operations, by design or by accident, substantially every form of myotomy or tenotomy that has yet been devised was put into practice. It is frequently stated that in these early operations it was customary to divide the belly of the muscle. This is quite erroneous. It was common in those days in writing about the operation to make no distinction between the tendon and the belly of the muscle, and the division of the tendon was as likely to be called a "myotomy" as a "tenotomy." Thus Mackenzie[13] heads his account of the operation "cure of strabismus by myotomy" although he does not mention any cutting of the muscle, but writes specifically of cutting the tendon. Later he speaks of "myotomy" or "tenotomy as it has been called." Some of the plates representing the operation give the impression that the muscular belly was to be cut, when the accompanying description shows that it was not. Thus Baumgarten[14] always speaks of myotomy, and his plate represents his strabismus hook under the belly of the muscle, two-thirds of an inch or more back from the margin of the cornea. Yet he describes his operation as cutting the tendon three lines from its insertion. Dieffenbach[15] and others did come to advocate cutting the belly of the muscle, to secure a greater effect in strabismus of high degree. But this was urged as an improvement or modification of the usual operation. In Dieffenbach's monograph, and again in his general treatise,[16] he describes the section as made in the tendon, three or four lines from its insertion, or for low grades of strabismus, directly at the insertion. Post,[17] whose monograph is dated June 5th, 1842, made a vertical incision one-fourth to one-half inch in length, "so as to expose to view the insertion of the internal rectus muscle." He expressly states "the division of the muscle should be as near as possible to its insertion." Although to secure a greater effect "it may perhaps be advantageous to divide the muscle one-sixth of an inch behind the insertion, and then to snip

[13]Mackenzie. *Diseases of the Eye.* 4th Edition, p. 361.

[14]M. Baumgarten. *Das Schielen und dessen Operative Behandlung.* Leipzig, 1841, 8vo., p. 88.

[15]Dieffenbach. *Schielen und die Heilung.* 1842. Berlin.

[16]Dieffenbach. *Die operative Chirurgie.* Leipzig, 1848, Bd. 2, p. 166.

[17]Post, A. C. *Observations on the Cure of Strabismus.* New York, 1841. 12mo., 50 pp., Illustrated.

with scissors the portion remaining attached to the sclerotica." This latter precaution was taken to avoid an "unseemly prominence," often amounting to a sort of fungous growth requiring subsequent snipping away, a complication which gave considerable trouble to the early operators for squint.

Duffin[18] ascribed some of the bad results of the early operators "to pushing the muscle back into the posterior and lateral part of the orbit with the handle of the scalpel, as has been recommended by some surgeons." His manner of dividing the tendon was "cutting it across with a pair of scissors inserted between the convexity of the hook and the sclerotic coat."

A general review of the causes for the relative discredit into which the operative treatment of strabismus shortly fell is thus given by Wilde:[19] "It is needless to add that many were operated on whose eyes should never have been meddled with. In some it failed for want of knowledge, or dexterity in the operation; a few were reduced to the condition exactly the reverse to what they were before the operation, and fully as bad, namely, that of extreme divergence; in some the eye becoming remarkably staring and prominent, resembling lagophthalmos; others squinted worse than before; several had the caruncle and semilunar fold of the conjunctiva completely cut away so as to leave a deep unseemly gap between the globe and the inner canthus of the eye, as where much violence was used in operating, particularly by those who poked into the orbit with a large dissecting forceps, to look for the muscle, without the aid of a blunt hook. In some the deformity, though relieved at the moment of operation, returned shortly after; and in several cases the squinting, though cured in the eye originally affected, seized upon the other afterwards."

Fifteen years later Graefe[20] and Critchett,[21] without suggesting anything radically new, but pointing out the dangers of recklessness and describing minutely a good technique, were able to impress upon the profession the operations which still bear their names. The discredit of the operative treatment of strabismus was, however, only relative. The operation was never given up. It merely lost the enormous popularity which it at first attained; and has never regained it since.

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[18]Duffin, E. W. Practical Remarks on the New Operations for the Cure of Strabismus or Squinting. London, 1840, 8vo., p. 147.

[19]Wilde, W. R. Description of a case of severe Trichiasis and Convergent Strabismus of Both Eyes, Successfully Treated by Operation. With an account of applying Ligatures on the Recti Muscles of the Eye. *The Dublin Journal of Medical Sciences*, 1845, Vol. XXVIII p. 201, 209.

[20] Graefe, A. Beiträge zur Lehre von Schielen und von der Schieloperation. *Archiv. für Ophthalmologie*, Bd. III, p. 177.

[21]Critchett. Practical Remarks on Strabismus and Some New Suggestions Respecting the Operation. *Lancet*, 1855, Vol. I, p. 507.

Dieffenbach did over 3,000 squint operations; and Guthrie,[22] in less than 7 months did 340 operations for internal, and 16 for external strabismus.

The use of the blunt hook now called the "strabismus hook" to catch up the tendon, is credited by Duffin to Lucas, who suggested it within the first few months following the introduction of the operation.[23]

Subconjunctival tenotomy was early proposed by Guérin,[24] and its relative merits were canvassed by the writers in those earlier years. Thus Hamilton[25] speaks of the advantages claimed for it, but concludes it is not to be preferred to the more usual open method. Guérin placed the patient in a horizontal position, had the lids separated by lid elevators, fixed the eye first with a hook implanted in the conjunctiva close to the cornea; and then introduced a second hook 6 or 7 mm. from the corneal margin at the insertion of the muscle, after which the first hook was removed. With a third hook the conjunctiva and fascia were taken up over one margin of the tendon about 5 mm. from its insertion. The tissues at the base of the fold thus formed were then punctured with a narrow double-edged knife. Through the puncture a bayonet-shaped tenotome was slipped between the sclera and the muscle, turned on its edge and made to cut through the tendon.

The so-called Critchett operation is a procedure which accomplishes the subconjunctival division of the tendon by methods more closely allied to the other popular forms of tenotomy for strabismus. It will be described among the operations still in use. Since Critchett published his method the most important modifications of tenotomy have been the method of Snellen; and its modifications, with the changes of the size and proportions of the instruments used by Stevens. These will also be referred to hereafter.

Of course each operator made some special modification in the technique which he considered an improvement; and considering that these early operations were done without anesthesia, and a generation before the advent of antiseptic methods, the technique was often admirable. We may illustrate by a brief outline of the operation as done by Bolton:[26] The patient's head was pressed against the chest of an assistant, who held open the lids. Fixation was usually secured by a

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[22]Guthrie, C. W. G. Jr. *The Results of the Operation for the Cure of Squinting at Royal Westminster Hospital,* April 18 to October 30, 1840.

[23]*Provincial Medical and Surgical Journal, October*, 1840; also *Practical Treatise on the Cure of Strabismus.* London, 1840, p. 48.

[24]Guérin. *Gazette Med. de Paris*, 1842, *X*.

[25]Hamilton, Frank H. *Strabismus*, 12mo., 69p. Buffalo, 1845.

[26]Bolton, James A. *A Treatise on Strabismus with a Description of New Instruments.* Richmond, Va., 1842, 12mo., 36 pl. with plate.

sharp hook passed deeply in the tissues near the caruncle. Bolton modified this sharp hook by adding a guard that could be turned over the point, so as to prevent it from injuring the lid, while rendering secure its hold on the tissue.

The fold of tissue was snipped and the "director" or strabismus hook introduced beneath the tendon. He modified the strabismus hook as shown in the accompanying diagram, Fig. 300, by placing a blunt barb on the end, to prevent the tendon from slipping off the hook before it was fully divided. Through the slit in the conjunctiva the hook-director was slipped between the internus and the sclera; and the tendon drawn forward with it. He says: "Then making the small blade of the scissors follow the silver director, with two or three clips I completely disengage it by dividing at once all the layers of tissue by which it is covered." "The operation occupies from one to two minutes." "The worse the squint the farther should the muscle be

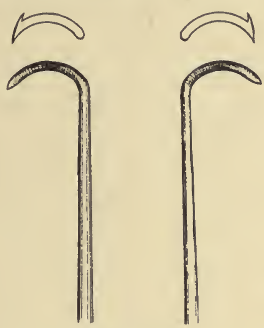

Fig. 300.
Double Curved Barbed Strabismus Hooks. (Bolton.)

divided from the ball." "The granulations which develop in about a fortnight form a fungous growth like a polypus, which is attached by a peduncle or a stem about the size of an ordinary knitting needle." This should be clipped close, or it might be touched with a pencil of nitrate of silver.

Baumgarten *(loc. cit.)* instead of dividing the tendon with scissors used a sharp knife, claiming that it caused less pain to the patient. Bonnet also raised the tendon and cut it from within outward with the cataract knife. The method of Guérin has been described above. Dieffenbach[27] and others, like Post, often excised a portion of the tendon.

Dieffenbach in his monograph (1842), mentions the use of a suture to diminish the excessive effect of tenotomy, and also the excision of tissue or cauterization at the insertion of the weakened mus-

[27]Dieffenbach. *Die Operative Chirurgie.*, Bd. II.

cle. In 1848 Cunier[28] suggested the use of the suture to prevent the sinking of the caruncle and apparent protrusion of the eyeball, an unsightly sequel of Dieffenbach's operation. He passed a suture by means of a fine needle through the middle of the lips of the incision held in position by hooks.

The *thread operation* is often credited to Graefe. But it was first suggested by Gulz and used by Dieffenbach in 1841. In 1842 after tenotomy of the external rectus for divergent squint Wilde used a ligature passed twice through the stump of the tendon and fastened to the nose by strips of adhesive plaster, taking care not to have the ligature touch the cornea. He first placed a strip of adhesive plaster on the nose, then drew the ligature over it sufficiently taut, placed a second strip over the ligature which was doubled back, and a third strip twice as wide over all. In 1845[29] he reported 18 cases treated in this way; 14 of convergent and 4 of divergent strabismus. The ligature was left so long as it remained tense. Wilde suggests using the ligature without cutting the tendon.

The first steps in the development of *advancement operations* appear in the case reported by Guérin.[30] Tenotomy of both internal recti had been followed by divergence; and tenotomy of the external rectus repeated three times failing to relieve the deformity, Guérin freed the eyeball from the temporal side, dissected up the remains of the attachment of the internal rectus muscle, drew it forward with forceps, and attached it to the sclera. He continues: "A last indication to fill, and one most important, was to keep the eye turned in, to place the insertion of the muscle and fascia at a point sufficiently anterior to oppose the return of the direction of the eye. I met this indication in the following manner: A waxed thread was passed by use of a curved needle through the thickness of the ocular fascia, near the external margin of the transparent cornea. The eye thus caught I drew in about one centimeter and kept it in that position by attaching the two pieces of thread to the bridge of the nose by adhesive plaster."

The advancement of Critchett, which will be described later, was first published in 1858, in the account by Bader[31] of a case treated at the Royal London Ophthalmic Hospital. The patient suffered from congenital divergent strabismus. Tenotomy of both externi, and turning the eyes in with a thread failed to correct it. A fortnight later

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[28]Cunier. *Bull. Acad. Roy. de Med. de Belge*, II, p. 158.

[29]Wilde. Description of a Case of Severe Trichiasis and Convergent Strabismus of Both Eyes, Successfully Treated by Operation; With Account of the Mode of Applying Ligatures on the Recti Muscles of the Eye. *Dublin Journal of Medical Science*, Vol. XXVIII, p. 201.

[30]Desmarres. *Maladies des Yeux*, p. 803.

[31]Bader. Report of Operations at the Royal London Ophthalmic Hospital for Strabismus. *Roy. London Ophth. Hospital Rep.* Vol. I, p. 250.

advancement was done on both the interni, giving as the ultimate result a very slight internal strabismus.

As one of the curiosities of surgical literature might be mentioned an operation described by Solomon,[32] for extreme divergent strabismus. A flap beginning 1 mm. from the nasal margin of the cornea was dissected back to include the internal rectus, and loosened sufficiently to stretch to the center of the cornea when the eyeball was in the median position. Then the external rectus was divided at its insertion, the conjunctiva anterior to the insertion of the externus was formed into a second flap which was turned over on the cornea, and to which the flap on the inner side of the eyeball was secured by three stitches. The central suture directly in front of the cornea was removed on the second or third day. The conjunctiva was allowed to shrink back and any uneven projections "trimmed off" at the end of two or three weeks.

In 1871, Weber,[33] published an operation for advancement with a single suture which never was much used outside of Germany. But the similar operation, described by de Wecker[34] in 1873, is often regarded as the beginning of modern advancement operations. The history of advancement operations is that of a multiplication of slight modifications in detail, rather than any progressive serial development. The time at which any particular operation was suggested is of interest only as bearing upon personal questions of priority. The more important of these dates are mentioned in connection with the descriptions of the operations.

GENERAL CONSIDERATIONS.

Classifications of Operations.

Most of the operations affecting the extrinsic ocular muscles are done for strabismus. These have been classified in various ways. The following plan seems to give the best comprehension of their purposes and relations.

(A) Operations done to diminish the influence of a particular muscle upon the position and movements of the eyeball, as tenotomy, and operations to increase the effect of tenotomy.

(B) Operations done to increase the influence of a particular muscle or muscles upon the position and movements of the eyeball, as operations for advancement, tendon-tucking.

(C) Operations to modify the influence of a particular muscle or

[32]Solomon, J. V. The Radical Cure of Extreme Divergent Strabismus. *Brit. Med. Jour.*, 1864, Vol. II, p. 671.

[33]Weber. A. Muskelvorlagerung. *Literature Verzcichniss.* No. 6, p. 415.

[34]De Wecker, L. De l'Avancement Musculaire au Moyen du double fil. *Annales d'Oculistique*, T. 70, p. 225.

muscles so as to change the direction in which it will tend to turn the eye, or to alter the relative proportions of the influences exerted in producing different movements, as by lateral displacement of the insertions.

(D) Miscellaneous operations to influence the position of the eyeball.

Combinations of two or more of these operations may be done as a single operation.

Since different operators use different operations for the relief of the same condition it will be convenient first to describe the separate operations; and then to consider in a general way the indications for their performance, and the relative advantages and disadvantages of various procedures that might be used for a certain condition. The designating of an operation by the name of its designer, while at first convenient, has now become an important source of confusion. The same operator has successively devised operations somewhat similar, yet bearing less resemblance to each other than to operations known by other names. This confusion increases with the multiplication and reduplication of operations proposed. Therefore the different procedures are here designated by characteristic features, rather than by names of operators who may have had some share in devising them.

The attention to the condition of the patient, the proper position, illumination and preparation of the eye, and the production of anesthesia are, in a general way, the same for all operations practised on the eye muscles; and may be here discussed together, in so far as special consideration is needed beyond what has been given in Part II.

Condition of the Patient.

Operations for strabismus are not emergency operations, and should be done when the patient is in the best possible condition. In young children the extent of the squint varies largely with the health of the child, and even with fatigue. Accurate, permanent correction can only be attained if the case has been studied with the patient in normal condition. Although the vascular tissues involved have great power of resisting infection, this ought not to be unnecessarily presumed upon. A case of total suppuration of the cornea, and subsequent shrinking of the eyeball in a boy of 16, has recently been reported by Wirtz.[35] The patient had just come from another hospital where he had been for three weeks on account of an angina, which, like the ocular infection, was later found to be due to a streptococcus. Erysipelas[36] from permanent streptococcus infection of the nasal si-

[35]Wirtz. Totale Vereiterung der Hornhaut nach einer Schieloperation. *Zeitschrift für Augenheilkunde*, January, 1910, p. 55.

[36]Holmes, C. R. Destructive Effects of Erysipelas on the Eye. *Am. Jour. Otology, Rhinology, and Laryn.* Sep., 1907.

nuses should be borne in mind. Recent influenza is especially to be guarded against because of its liability to attack the eye, and because the patient may attach little importance to it if the preceding symptoms have been slight. As in preparing for all other operations, hemophilia should be inquired for. It has caused bleeding lasting for many days, and might cause death. An operation should not be undertaken in the presence of trachoma, or lachrymal conjunctivitis, or even chronic blepharitis, without trying to bring the eye into the best possible condition for it.

Position for Operation.

One may operate with the patient seated or lying down, but in either position the back of the head should be fully supported. The illumination should be clear, and may come from a broad source. Corneal reflexes, that may embarrass the operator in doing a cataract extraction or iridectomy, do not interfere with operating on the eye muscles.

Anesthesia and Hemostasis.

For local anesthesia many operators depend upon a solution of cocain instilled into the conjunctiva for twenty minutes before beginning the operation; or crystals of the cocain salt laid on the conjunctiva over the tendon to be divided. Some use the cocain solution or crystals again after opening the conjunctiva and capsule. Browne[37] devised a perforated tube, shaped like a strabismus hook, with which he injected a cocain solution beneath the tendon before dividing it. Woodruff[38] raises the conjunctiva with forceps and injects a 1 per cent. cocain solution mixed with one to one thousand of adrenalin beneath the conjunctiva; and massages the resulting swelling for a few minutes. More efficient means are recommended by Bruns[39] of injecting a solution containing cocain and adrenalin, dissolved in physiologic salt solution, along the course of the muscle to be operated on, five to eight minutes before beginning the operation.

It is a great convenience to have oozing controlled by the application of one of the suprarenal preparations. By this resource and care to avoid cutting the larger visible vessels, troublesome bleeding may be avoided in most cases. A solution of adrenalin of quite moderate strength, 1 to 2,000 or less, is quite sufficient. Two or three drops should be applied about two minutes before beginning the cut-

[37]Browne, A. E. A Cocain Strabismus Hook. *Brit. Med. Jour.*, 1887, Vol. II, p. 1277.
[38]Woodruff, H. W. Shortening of an Ocular Muscle by Tucking. *Jour. Ophth. and Oto-Laryngol.* April, 1910.
[39]Bruns, H. D. Ophthalmic Surgery. *New Orleans Med. and Surg. Jour.* Dec., 1909.

ting. Local anesthesia is sufficient for any of these operations, when done by one thoroughly familiar with the procedure, upon an adult who possesses good self control. But for young children and nervous excitable adults, general anesthesia is necessary for an accurate and satisfactory operation. General anesthesia is more necessary for advancement operations, with accompanying division of the advanced tendon, than for simple tenotomy, or tendon tucking. In an advancement the success of the operation depends upon the accurate placing of the sutures.

Instruments Required.

These are a stop speculum, lid elevator, various forceps, scissors, strabismus hooks, needles and sutures. The speculum may be any of the standard forms. If the operation is done in a sitting posture a short, light speculum, like that of Mellinger, as adapted by Beard, is to be preferred. If the patient is in the recumbent position a heavier instrument, such as the Moorfields model, may be quite as satisfactory. For these operations it is not of such great importance that the instrument be instantly removable as that it be firm and rigid.

The forceps may include the usual broad serrated conjunctival fixation forceps, although these are not necessary. Fine-toothed forceps can be used to seize the conjunctiva, and such are necessary for accurately seizing and lifting the deeper connective tissue structures. For fixing the eyeball during the introduction of a stitch into the sclera, the crossbill, embedding, fixation forceps of Critchett are often most satisfactory. The points are brought together on the surface of the sclera and then thrust into it as the handles are pressed together.

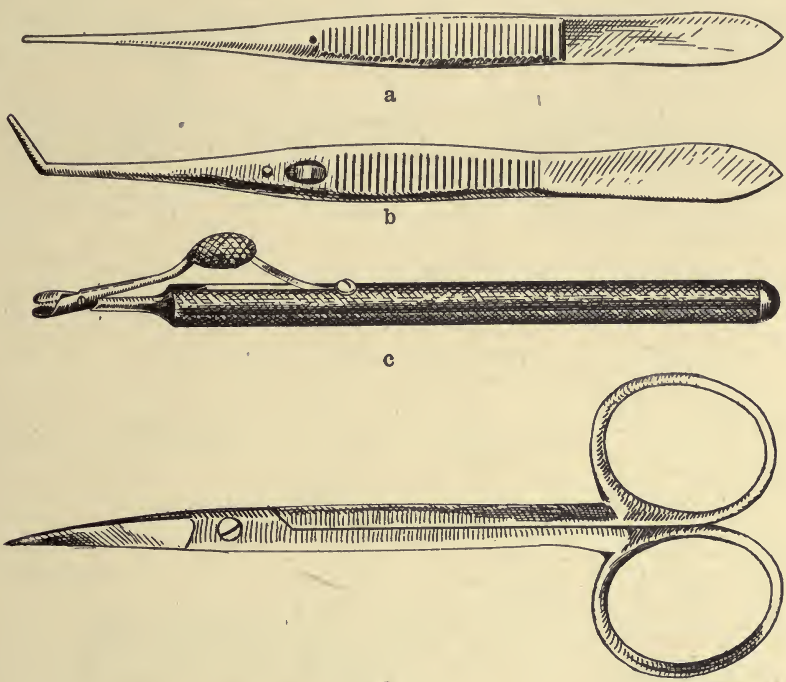
For seizing the tendon the advancement forceps, as those of Prince, with a spring or sliding catch are needed. Needle forceps should be adapted to holding small needles, and allowing a ready release. No spring or slide catch is required. The instrument of Stevenson is satisfactory.

The scissors should be slightly curved on the flat, about 40 mm. radius, with fine rounded points. From the joint to the point should be between 20 and 25 mm. The handles may be either of the ordinary form, or the forceps handles suggested by the writer in 1890[40]; and independently by Wescott,[41] who combined them with the narrow rounded points of the Stevens' scissors. The forceps scissors are easier to use in any direction without the operator having to change his position. It is essential that the scissors should cut perfectly, as the recti tendons and their finer prolongations most readily slip between the blades, if

[40]Jackson, E. Scissors for Tenotomy. *Med. News*, LVI, p. 184.
[41]Wescott, C. D. A New Tenotomy Scissors. *Ophth. Rec.*, 1897, p. 486.

these are not accurately adjusted or not heavy enough to prevent springing.

The strabismus hook should be rather delicate, the one most used about ¾ of a mm. thick at the curve, the end slightly bulbous, projecting 7 or 8 mm. from the direction of the shank and slightly bent back, making a curve of more than 90 degrees. Hooks larger, projecting 10 or 11 mm., and smaller, projecting 5 or 6 mm., may also be used. But the very fine hooks are liable to catch in connective tissue structures where it is desired that they should glide smoothly past. The double, or clamp hook of de Wecker is used by some operators, but many find



a

b

c

d

Fig. 301.

Instruments Generally Used in Muscle Operations:

a Strabismus forceps.
b Prince advancement forceps.
c Stevenson needle forceps.
d Strabismus scissors, ordinary form.

the tendon forceps a more convenient instrument. The hook of Clark and various tendon tuckers will be described in connection with the operations for tendon tucking.

The needles should be curved. The smallest obtainable are to be used for placing stitches in the sclera. A size somewhat larger is better for conjunctival or subconjunctival stitches. The suture material is usually silk, as large as can be conveniently threaded in the needle

used. A difficulty with sutures employed in these operations is the tendency to cut out prematurely. Catgut may be employed and presents advantages for buried sutures in advancement operations. But it is inferior to silk in that it is less flexible, and more bulky for a given tensile strength.

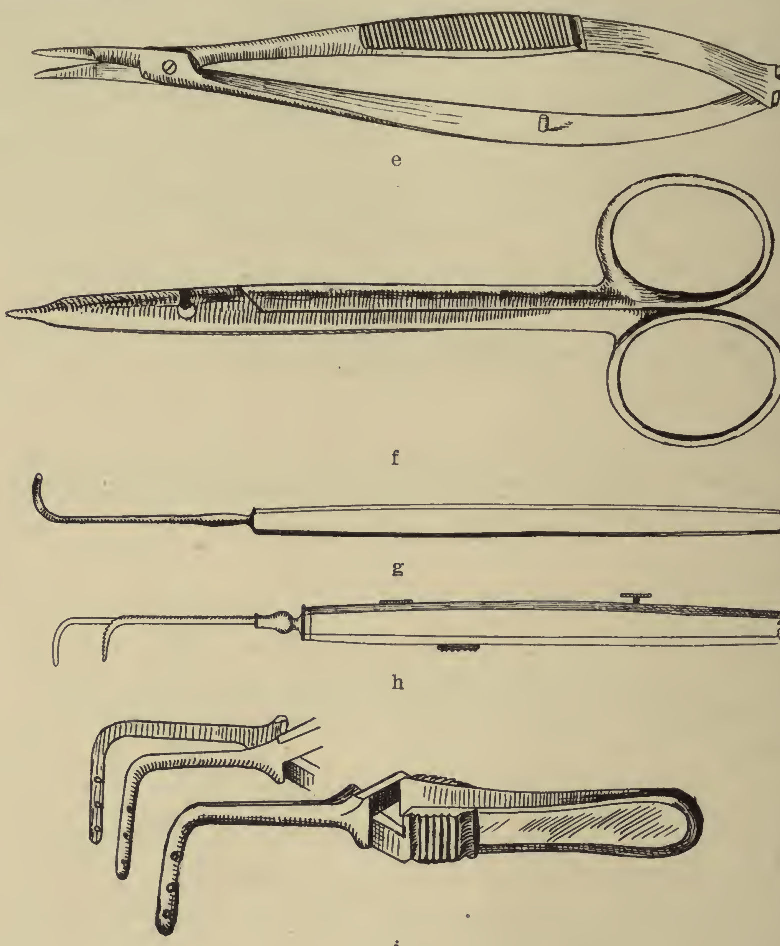


Fig. 302.

Instruments Generally Used in Muscle Operations (Continued).

e Strabismus scissors with forceps handles.
f Stevens strabismus scissors.
g Strabismus hook.
h de Wecker's double hook clamp
i Howe's muscle clamp.

Other instruments employed only in particular forms of operations will be described in connection therewith. The strabismus instruments should be made entirely of metal, and rendered aseptic by brief boiling.

A.—OPERATIONS TO DIMINISH THE INFLUENCE OF A MUSCLE. TENOTOMY.

Tenotomy by the Open Method.

This is the operation which has been most widely practised for strabismus. It was, in the main, the method of the early operators, and was reformulated by Graefe. The instruments required are the speculum, fine strabismus forceps, strabismus hook, scissors, needles, silk and needle forceps for the conjunctival suture.

The speculum is introduced in the eye to be operated on, and the other eye is closed. For *tenotomy of the internal rectus* the patient is directed to turn the eyes to the side of the one to be operated on, relaxing the contracted muscle, and thus rendering the fixation of the eye in proper position easier for the surgeon, and less uncomfortable for the patient.

The operator stands at the head, or either side of the patient; whichever will interfere least with the light, and give the readiest access to the tendon. Usually with the patient recumbent, standing by the right side gives freest access to the right eye, and by the left side for the left eye. Taking the forceps in the left hand and the scissors in the right, the conjunctiva and subconjunctival tissue are seized over the insertion of the tendon, 6 mm. to the nasal side of the corneal margin, in such a way as to raise a horizontal fold of tissue. This fold is cut with the scissors so as to make a vertical conjunctival incision 8 or 10 mm. long, parallel with a tangent at the nasal margin of the cornea. Graefe[42] made the incision nearer the cornea. Schweigger[43] insisted on placing the incision directly over the insertion. Any episcleral tissue remaining undivided by the original cut is then picked up with the forceps, and the incision completed down to the sclera. With the point of the closed forceps, or the point of the closed scissors, a little blunt dissecting is done at the lower angle of the wound, downward and backward 3 or 4 mm. to get beneath the lower margin of the tendon.

The scissors are then laid aside, the forceps are used for fixation; and the strabismus hook, held in the right hand, is entered with its tip in the channel just prepared, passing first downward and backward 3 or 4 mm. The tip being pressed firmly against the sclera is then carried upward about 10 mm., the hook being so held and turned as to follow its tip with the least traction or disturbance of tissue. The bulbous tip is then allowed to leave the sclera, being slightly elevated, and brought forward toward the cornea until arrested by the tendon at its insertion.

The assistant may now sponge the wound, and the surgeon should

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[42]von Graefe, A. Beiträge zur Lehre vom Schielen und von der Schieloperation. *Arch. f. Ophthalmol.* Vol. III, p. I, p. 177.

[43]Schweigger's *Handbook of Ophthalmology.* Tr. by Porter Farley, Philadelphia, 1878, p. 175.

see that the whole width of the tendon is held upon the hook. It is safest to make the end fairly emerge above the upper margin of the tendon. To accomplish this the subconjunctival wound may be slightly stretched upward with the point of the forceps, and the tissue teased through to the end of the hook; or the hook may be liberated by snipping the tissue overlying the point with the scissors.

The fixation of the eye may now be accomplished entirely by the hook. This is the time for special stretching of the muscle, to be alluded to later. In any case the tension on the muscle, almost inevitably resisted by the patient, is the cause of serious discomfort—the most painful part of the operation. On this account this stage must not be unnecessarily prolonged. The hook is now transferred to the left hand of the operator, and the scissors are taken in the right hand. One blade is slipped between the hook and the sclera behind the tendon, the other passing in the wound in front of the insertion. The tendon

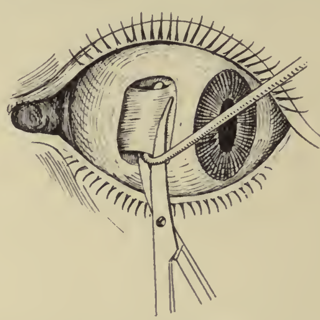

Fig. 303.

Tenotomy by the Open Method. Tendon Held on Strabismus Hook. Scissors Introduced.

is now divided as close to the insertion as possible without actually cutting into the sclera. See Fig. 303. This is generally done by three or four snips; because this does not require so much displacement of the parts, as it does to thrust the scissors all the way beneath the tendon, and divide the whole at one cut. The latter plan, however, may be safer for the inexperienced operator. With the complete division of the tendon the hook comes forward out from the conjunctival wound, or slips beneath the conjunctiva up to its attachment at the corneal margin.

The wound may now be cleansed and the result inspected. A finger or the handle of the hook being held before the eye, for the patient to fix, is carried to or from the middle line, to show the freedom of movement. The other eye should be uncovered, and the relative positions of the two compared, by noticing the positions of the reflections of the window, or other source of light, on the two corneas.

If the effect of the operation seems less than desired the eye may

be fixed by the forceps, catching in the limbus of the conjunctiva; and the hook introduced with the tip turned down and backward to pass behind and below the original point of first introduction in search of any undivided attachment of the tendon to the sclera below. Any such attachment found should be held on the hook and divided with the scissors as was the main insertion. Then the hook may be again swept back and upwards and drawn forward to discover any undivided attachment in that direction. If no such structure is caught the hook will pass freely forward to the limbus.

To complete the operation the needle is grasped with the needle holder in the right hand and entered half way between the corneal margin and the center of the wound, through the conjunctiva steadied by the fixation forceps. The needle is then carried under the conjunctiva to a corresponding point on the nasal side of the wound, drawn through, and the suture tide with very moderate tension. Blood clots are to be washed away, and the eye closed and covered for a few hours, or until the next day, with a light dressing.

Complications.

The most frequent and serious complication is excessive hemorrhage. This hides the steps of the operation, prolonging it and causing uncertainty as to exactly what is being accomplished. The blood comes either from minute vessels, the necessary oozing accompanying such incisions; or from larger vessels, particularly veins that chance to be located in that portion of the conjunctiva or subconjunctival tissue, or which pass close under the tendon to enter the sclera. The oozing can be almost wholly controlled by the previous instillation of one of the suprarenal preparations. The larger superficial vessels are visible on careful inspection, and may be avoided by limiting or shifting the incision. The conjunctiva and subjacent tissue are so readily pushed aside, that a moderate variation in the position of the opening made in them need interfere but little with the subsequent steps of the operation. The presence of an unusually large vessel stretched beneath the tendon cannot be known until it is cut. This is a reason why the tendon should be well included in the hook before attempting to cut it; and why it is safer for the beginner to pass the blade of the scissors entirely beneath the tendon so as to divide its whole width at a single stroke. If these points are attended to it will very rarely be needful to delay the operation on account of excessive hemorrhage.

Perforation of the sclera by the point of the scissors has occurred to skillful and experienced operators.[44] Knapp ascribed it in his cases

[44]Derby, H. Two Cases of Penetration of the Eyeball by Scissors During the Operation for Strabismus—Recovery. *Tr. Amer. Ophth. Soc.*, Vol. IV, p. 33.

to the use of scissors with perfectly sharp points. Czermak [44a] says it occurs when the scissors are directed beneath the tendons somewhat obliquely from behind. The pressure of the tendon on the blade thrust beneath it causes its point to penetrate. The danger is avoided by having the scissors parallel to the line of tendon insertion with the convex surface turned toward the sclera. The concavity of the curved scissors fits the sclera more closely, when the instrument is applied exactly upon the eyeball. But with the convexity turned toward the eyeball, the handles are in much more convenient position. And where the tendon is divided by two or three snips the section can be made closer to the insertion with the convexity toward the globe than it can be with the concavity turned to the insertion, and the scissors thrust under the whole width of the tendon to divide it at one cut, because of the greater thickness of the blades as we depart from the points. If the sclera has been penetrated the division of the tendon may be completed or deferred. After the operation the eye should be dressed and treated as after a cataract extraction.

Multiple insertions of the tendon are quite rare, yet the possibility of their occurrence should be borne in mind. Wicherkiewicz[45] reported a case in which the internal rectus was inserted by two tendons separated from each other by an interval of 4 mm. Sometimes the insertion instead of being an approximately straight line or slight curve, is quite irregular in outline. This liability to such irregularities is the reason for sweeping the hook rather more freely behind the insertion, than would otherwise be necessary. Rarely does the insertion depart from approximately its usual situation. But sometimes tenotomy is attempted upon a muscle that has previously been subjected to the same operation. In such a case the operator will generally find little resemblance to the normal tendon and its insertion in the broad mass of scar tissue, which may be widely attached to the sclera, and also to the orbital connective tissue. Velhagen[46] found the muscle drawn 7.5 mm. back of its original insertion, with sclera, capsule, muscle extremity and fascia all united by scar tissue.

Effect of Tenotomy of the Internus.

Insufficient effect produced by simple tenotomy will generally be met by resort to some modification, or extension of the operation, as described in connection with other forms of operations. Excessive effect should rarely occur if the preliminary study and management of the case are carried out with attention to the details to be mentioned in

[44a]Czermak, W. *Die Augenärtzlichen Operationen*, p. 498.

[45]Wicherkiewicz, W. B. Ueber eine abnorme Insertion des Rectus Internus. *Klin. Monatsbl. f. Augenheilkunde*, Feb., 1907, p. 200.

[46]Velhagen, V. C. Ueber die Narbenbildung nach der Tenotomie am menschlichen Auge. *Klinische Monatsbl. f. Angenh.*, 1909, Beilegeheft, p. 19.

the sections on indications. If, however, decided turning out is manifest at the close of the operation, a stitch may be placed in the retracted tendon and surrounding tissue, and secured anteriorly as for an advancement. Or the external rectus may be thoroughly stretched; or a thread passed through its insertion and secured to the bridge of the nose, in the manner described by Wilde, to keep the eye somewhat in convergence until the divided muscle has time to reattach itself.

One need not attach very great importance to the apparent position of the eyes at the close of the operation, if the degree of squint has been carefully ascertained, and the operation properly planned to correct it before beginning to operate. The effect to be aimed at in any tenotomy for convergent squint is something of an *under-correction* of the existing squint. It is always to be remembered that the internal rectus is not the only muscle that acts to turn the eye in. The superior and inferior recti, especially their internal fibres, assist under normal conditions; and help still more to produce convergence when the eye has already been turned in, as in convergent strabismus. Under these circumstances the division of the internus producing some diminution of convergence is generally followed by relaxation of the nasal portions of the superior and inferior muscles, which still further diminishes the turning in.

The alteration to be expected in the direction in the visual axis from simple tenotomy of the internal rectus, varies with the degree of strabismus. In low degrees of convergent strabismus the convergence depends chiefly on contraction of the internal rectus muscle, and simple division of its tendon is likely to produce a change of direction of 2 or 3 mm., 10 or 15 degrees. When the convergence is of very high degree it depends largely on the contraction of the nasal fibres of the superior and inferior recti; and simple division of the internus may produce no perceptible effect. The statement is often made that 18 or 20 degrees of squint, or even 25 degrees (4 to 5 mm.) may be corrected by simple tenotomy. But where such an effect is produced the operation has usually gone beyond simple division of the tendon at its insertion. A squint of this amount may be so much reduced as to appear corrected. But this will be only when the deviation was not greater than the amount named to start with, and then a slight convergence will usually be shown by exact measurement.

Sequels and After Treatment.

The *exuberant granulation,* or fungus growth, which the earlier operators looked upon as an ordinary sequel, is now rarely seen. It probably arose from the leaving of a stump of the insertion uncovered by the conjunctiva. To prevent such a growth is an important reason

for dividing the tendon directly at its insertion into the sclera; and also for bringing the conjunctiva together by a stitch at the conclusion of the operation by the open method. Its formation may also be favored by prolonged or excessive bandaging. Should it arise, the old methods of snipping with the scissors, or touching with silver nitrate are still applicable.

Excessive *hemorrhage* is apt to be followed by retention of blood in the subconjunctival tissue. An advantage of the open method is that it promotes the free escape of the effused blood. But this advantage is only gained by waiting for the bleeding to cease before introducing the suture. The operation is followed by swelling and hyperemia of the parts involved; that do not wholly subside for several weeks. Ultimately the point of original insertion of the tendon and the sclera behind it, exposed by the retraction of the tendon, can generally be seen through the conjunctiva.

A more important sequel is *retraction of the caruncle,* which gives the eye a staring look and an appearance of exophthalmos. Actual protrusion of the globe does not occur unless the suspensory fascia of the orbit has been considerably injured. The falling of the caruncle is guarded against by the conjunctival suture, and by dissecting between the tendon and the caruncle, before raising the tendon to divide it.

Howe believes that retraction of the caruncle may depend on retraction of Horner's muscle.[47] He has sought to remedy it by tenotomy of that muscle. This is effected by seizing the caruncle with forceps, drawing it towards the cornea, entering a narrow cataract knife at the extreme inner canthus to the nasal side of the caruncle, parallel to the inner wall of the orbit, and cutting both ways to divide all the fibres of the muscle. To prevent immediate union of the fibres the upper and lower ends of the vertical linear wound thus made are brought together by a suture; carried from beyond one extremity of the wound to beyond the other by a small curved needle. The caruncle may also be loosened from the underlying tissues and advanced towards the cornea by a suture resembling one of those used for muscular advancement. But usually in cases of this deformity the advancement of the internus muscle is also advisable; and in doing this the adjoining tissues including the caruncle can be brought forward together, as in Critchett's advancement operation.

After Treatment.

The eye being cleansed at the close of the operation is usually

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[47]Howe, L. The Muscle of Horner and Its Relation to the Retraction of the Carnucle After the Tenotomy of the Internal Rectus. *Tr. Amer. Ophth. Soc.*, X, p. 319.

covered with some form of dressing, as gauze or cotton, held in place by adhesive strips, a roller bandage, or one of the special forms of eye bandage. Operators sometimes permit the eye to go without any dressing. Others keep it closely bandaged for 3 or 4 days. The writer prefers a light dressing retained by adhesive strips, to remain on until the next day. After this the cleansing of the eye by a boric acid, or physiologic salt solution, is all the treatment required.

Variations in Tenotomy by the Open Method.

It is stated by Taylor[48] that Graefe usually introduced the hook beneath the upper edge of the tendon, and cut from above. Taylor introduced the hook from below, and then after freeing the point with the snip of the scissors divided the insertion from above downwards thus avoiding all tendency of the tendon to slip off the hook.

Instead of making the conjunctival incision vertical, parallel to the corneal margin, it may be made horizontal, radiating from the center of the cornea. To do this a vertical fold is seized and snipped through horizontally, making an incision 8 or 10 mm. long, the center of which should be placed over the insertion of the tendon. To introduce the hook beneath the tendon the conjunctiva must be pushed aside, upward or downward. The exposure of the insertion is not so complete. But on the other hand this radiating incision is less likely to divide large vessels passing forward toward the corneal margin, and there is much less gaping of the incision, less danger of sinking of the caruncle, and no need to introduce a stitch to prevent this unpleasant result.

Tenotomy without the Hook.

Some operators have preferred to divide the tendon without using the strabismus hook, notably von Arlt, Schweigger, Fuchs, and Meller.[49] The conjunctival and subconjunctival tissues are incised as for the open method, first described. With the end of the closed strabismus forceps the tissue overlying the tendon is pushed back 3 or 4 mm. from the insertion. The forceps are then opened and made to grasp the whole width of the tendon, as nearly as possible; which is then pulled up from the sclera and divided with the scissors. Having done this, however, most operators use a small strabismus hook to catch up any portion of the tendon remaining undivided, which is snipped through as previously described. By this method a skilled operator can do tenotomy very quickly. But it requires a full-sized incision parallel to the margin of the cornea, to be closed afterwards

[48]Taylor, C. B. Operative Treatment of Squint. *Brit. Med. Jour.*, 1887, II, p. 1275.
[49]Meller, J. *Ophthalmic Surgery*, Amer. Ed., p. 84.

with a stitch; and is liable to cause more disturbance of adjoining structures than the ordinary use of the hook.

Subconjunctival Tenotomy.

The instruments required are the same as for tenotomy by the open method, except that a needle and suture are only needed for certain emergencies. The operation consists essentially in dividing the tendon through a small opening, usually not directly over the insertion, but placed so close to the tendon that the opening in the loose conjunctiva can be pulled over the insertion of the tendon; and it is generally so drawn at some time during the operation. The method resorted to by Guérin has been described, on account of its historic interest. The procedure of Critchett[50] is more widely popular and is still used.

It begins by seizing the tissue over the lower margin of the tendon just back of its insertion; and cutting it with the scissors in such a way as to give a conjunctival incision 5 or 6 mm. long and parallel to the margin of the tendon. The deeper tissue is raised with the forceps and the incision carried down to the sclera.

The tip of a large strabismus hook is then pressed against the sclera and carried backward and upward beneath the tendon until it can be seen to emerge under the conjunctiva at the upper margin. The hook is drawn forward so as to put the muscle on the stretch and slightly raise the tendon from the sclera.

The points of the strabismus scissors are now introduced, closed, within the conjunctival incision; and then slightly opened. One blade is pushed beneath the tendon, between the hook and the sclera. The other blade is pushed in front of the insertion of the tendon, under the conjunctiva. The tendon is then divided at its insertion by two or more snips. If the division of the tendon is complete, and the effect produced satisfactory, this completes the operation. If the effect is not so great as was expected, the hook may be swept around to catch any undivided slips of tendon, and these cut as after the open operation.

There is especial liability for the upper fibres of the tendon to slip off before they are divided. It was to guard against such an accident that Theobald[51] proposed his crochet hook, having a barb on the tip like that of a crochet needle; somewhat like Bolton's instrument (See Fig. 300), but the barb toward the concavity instead of at right angles thereto. Critchett advised, to complete such an incomplete tenotomy, the making of an incision close to the upper border of the

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[50]Critchett. Practical Remarks on Strabismus and Some New Suggestions Respecting the Operation. *Lancet*, 1855, Vol. I, p. 507.

[51]Theobald, S. An Improved Strabismus Hook. *Amer. Jour. Med. Soc.*, Vol. 63, p. 405.

tendon, similar to the one that had been made below; and introducing the hook and dividing the remaining part of the tendon from above.

Snell[52] adopted the practice of dividing the whole tendon from above, and reported 100 cases in which the operation had proved most satisfactory. He preferred this plan because the operator could stand behind the patient, who was not compelled to see the instruments; and it caused less sinking of the caruncle, because the caruncle is more closely associated with the conjunctiva below than above. In a case of free hemorrhage he made a counter puncture in the lower part of the conjunctiva.

The tendon can be divided through a radial incision in the conjunctiva placed anywhere close to the insertion. The writer has most frequently done it through an opening placed a little above the lower edge of the tendon. This gives somewhat easier access to the upper fibres than an incision below the lower margin, yet it is low enough for drainage. The incision might be made in size or position anywhere intermediate between the radial incision for the open method, and the Critchett or the Snell incisions, and the modifications next to be described. The incision should be differently placed in different cases, chiefly to avoid the cutting of the larger vessels and causing troublesome hemorrhage.

Snellen[53] picked up the conjunctiva and capsule in a horizontal fold, directly over the center of insertion of the tendon. This is cut with the scissors; making a small vertical incision. The center of the tendon close to its insertion is then seized with the forceps, raised from the sclera and snipped through, making a small button-hole opening in the center of the tendon at its insertion. Through this a small strabismus hook is introduced beneath the tendon and turned upward. See Fig. 304. That portion of the tendon is raised, the point of the scissors introduced, one blade passed behind and the other in front of the insertion, and the upper half of the tendon divided. Then the hook is turned downward, and the lower half of the tendon divided in the same way. This operation is the basis of the Stevens' operation of partial tenotomy to be described later. It does tenotomy with less disturbance of structures, other than the tendon to be divided, than any other form of operation. If, on account of free hemorrhage, or to get an increased effect, such a step becomes advisable, it can instantly be converted into a tenotomy by the open method.

Tenotomy of the External Rectus.

Either of the operations above described, as done on the internal

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[52]Snell, S. The Etiology and Treatment of Convergent Squint. *Brit. Med. Jour.*, 1887, p. 660.

[53]Snellen, H. *Klin. Monatsbl. f. Augenh.*, 1870, p. 26.

rectus muscle, may be done on the externus, with the same instruments and with but little modification of technique. They require the same preparation and after treatment. The field for operation on the externus is a little more readily accessible. There is still less likelihood of being hindered by excessive hemorrhage, no risk of sinking of the caruncle, and no danger of an excessive effect. The insertion of the external tendon is slightly farther back from the cornea. The incision for the open operation may be 7 or 8 mm. from the clear cornea. There is more room for the radiating incision for a subconjunctival operation; and more free space for the manipulation of the handles of the strabismus hook and scissors. Even after an open operation a suture is not essential. But it will facilitate healing when the conjunctival opening is more than 6 or 7 mm. long.

Tenotomy of the External Rectus by Subconjunctival Method.

The instruments required are a speculum, strabismus forceps, scissors, and strabismus hook. The lids being separated by the specu-

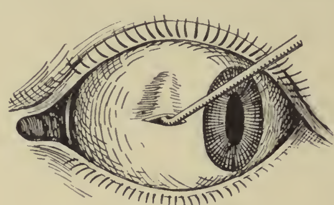

Fig. 304.

Tenotomy by the Subconjunctival Method of Snellen. Upper half of tendon raised on the hook.

lum, the eye is turned strongly toward the nose. The fixation forceps with their tips separated about 6 mm. are applied to the conjunctiva and brought together so as to raise a vertical fold 6 mm. from the corneal margin. This fold is snipped with the scissors in such a way as to make a conjunctival incision 5 or 6 mm. long and 4 mm. below the horizontal meridian of the eyeball; the incision being over the lower part of the tendon insertion, and parallel to the lower margin of the tendon. The point of the scissors is then introduced beneath the conjunctiva, and by blunt dissection with the scissors closed, and a few short snips, the more superficial tissue is separated from the insertion of the tendon. The point of the scissors is then turned downward and a similar tunnel carried below the margin of the tendon.

The larger strabismus hook is entered at the incision, and its tip carried downward and backward 4 or 5 mm. It is then turned upward and backward, and the hook swept beneath the tendon. One blade of the scissors is introduced beneath the hook and carried along it as a guide beneath the tendon. The other blade is introduced over, or in front of the insertion of the tendon, in the tunnel opened by

blunt dissection. The tendon is then divided at its insertion, care being taken that the upper margin shall not escape from the hook before it is fully divided. Such escape may be prevented by shifting the hook slightly after the lower part of the tendon has been divided in such a way that the tip shall point farther forward above the upper edge of the tendon, the curve of the tip lying beneath the tendon slightly back from the insertion. By slight pressure of the strabismus hook on the conjunctiva after the division of the tendon has been completed the effused blood may usually be expelled. No suture is required. The after treatment is similar to that for tenotomy of the internus.

Effects of Tenotomy of the Externus.

Tenotomy of the externus produces less effect on the position of the eye than tenotomy of the internus. This has been noticed by operators from the early days of squint operations. There are several reasons for it. Parallelism and convergence of the eyes are attained and kept up by neuro-muscular effort. Divergence is a passive condition which usually appears at death, in coma, in profound general anesthesia; or when, on account of blindness, in one or both eyes, binocular vision is given up. This was pointed out by Hansen Grut.[84] Convergence is a function lately acquired in the process of animal development: Most of the lower animals have their visual axes widely divergent. Hence, when the eyeball is released from the influence of muscular contraction, it is more likely to assume the divergent position. Division of a muscle is followed by some inhibition of the action of its antagonist; and probably of the actions of all the other extrinsic ocular muscles. Tenotomy, therefore, leaves the position of the eyes less under neuro-muscular influence, and more under the control of the connective tissue attachments of the globe. This tendency with relaxation to take the position of divergence, favors increased effect of tenotomy of the internus, but diminishes the effect of tenotomy of the externus. The shorter contact arc of the internal muscle, almost annihilated by tenotomy, also places that muscle at a permanent disadvantage after such an operation. The contact arc of the externus remains after tenotomy as long as that of the normal internus, so that no limitation of movement need follow from a reduced contact arc. Again the obliques seem more free to act together, as secondary abductors than are the superior and inferior recti to act together as adductors when the respective lateral muscles which they assist have been cut.

The effect secured by a tenotomy of the externus is, therefore, but one-third or one-fourth that obtained by tenotomy of the internus

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[84] Grut, H. The Pathogeny of Divergent and Convergent Strabismus. *Ophth. Rev.*, Vol. 9, 1890, p. 16.

not over 1 mm., or 2 to 5 degrees. The effect at first is greater than this. But it tends to diminish, while the effect of tenotomy of the internus is likely to increase for some weeks after operation. The small ultimate effect produced by tenotomy of the external rectus limits the range of its application to use in heterophoria; or as a last exact adjustment of a slight divergence left by previous operations or as an adjunct to advancement of the internal rectus.

Tenotomy of the Superior and Inferior Recti Muscles.

In general the same operations may be done on these muscles as on the lateral recti. The same preparations and after treatment are required. But upon the inferior and superior recti operation is more difficult than on the lateral muscles. This is especially true of the superior rectus, because the insertion of the tendon is farther back from the corneal margin, and there is a general tendency to roll the eye up when it is attacked. It is better to use a lid elevator or a speculum with a solid lid holder, which keeps the lashes out of the field of operation, and lessens the need of special watchfulness to avoid cutting the lashes or the lid margins. Otherwise the instruments required are the same as for tenotomy of the lateral recti.

For both the superior and inferior recti an operation rather like the subconjunctival tenotomy of Snellen, with a slightly larger opening in the conjunctiva, effers positive advantages. The approach to the field of operation can be made from directly in front, where there is more room for the manipulation of instruments. Then the secondary insertions of the superior and inferior muscles, by which, in part, the movements of the lids are closely associated with those of the eyeball are more extended and more important than the corresponding connections of the lateral muscles. These connections cannot be impaired with advantage; and they are least likely to be disturbed by cutting the tendon each way from its center. It is unnecessary to work through a particularly small conjunctival opening, or to use a suture, for the tendency to gape of a wound perpendicular to the margin of the cornea is very slight, and the wound is habitually well covered by the corresponding lid.

Tenotomy of the Superior Rectus.

The upper lid is well raised by an elevator held by the assistant and the eye turned strongly down. The conjunctival incision is made parallel to the vertical meridian of the eyeball either in or at 4 mm. to the temporal side of the vertical meridian, commencing 3 mm. above the corneal margin and extending up and back 5 or 6 mm. The incision is carried down to the sclera and tendon, and the episcleral tissue tunnelled, chiefly by blunt dissection along the whole line of in-

sertion of the superior rectus muscle. Either the tendon is cut at the middle, or the strabismus hook is introduced and the conjunctival wound dragged over entirely to the temporal side of the tendon insertion. The tip, then held in contact with the sclera, is carried beneath the tendon across to its nasal margin. The scissors are entered through the conjunctival opening with one blade in contact with the sclera, the other in front of the insertion, and the tendon divided at its insertion.

It should be borne in mind that the insertion of the superior rectus is farther back from the corneal margin than the insertion of the other recti muscles, and is more frequently irregular. The introduction of the hook beneath the temporal side of the tendon avoids the risk of catching any portion of the tendon of insertion of the superior oblique.

The after treatment is similar to that of tenotomy of the other recti muscles, except that the situation of the wound is well beneath the upper lid where it will be irrigated by the secretion of the lachrymal gland, rendering any dressing quite unnecessary.

Tenotomy of the Inferior Rectus.

For this operation a stop speculum should be used, and the eye turned strongly up. The operation otherwise resembles that of tenotomy of the superior rectus. The introduction of the hook beneath the temporal side of the tendon lessens the risk of disturbing the inferior oblique, through the attachments that connect that muscle with the inferior rectus. After operation the eye should be dressed and treated as after tenotomy of the internal rectus.

Effect of Tenotomy of the Superior or Inferior Rectus.

The amount of change in the direction of the visual axis to be expected is somewhat uncertain. Cases have been reported in which the change that followed operation was unexpectedly great and correspondingly annoying. The writer's personal experience would lead him to expect a change of 8 to 10 degrees, about one-half that produced by tenotomy of the internus. But no one operator sees many cases suitable for these operations. Knapp[55] thinks the effect produced is distinctly greater than that of tenotomy of the external rectus, but that it tends to diminish in the course of a few weeks. The choice between the different muscles on which an operation might be done, and the particular operation to be done in a given case, will be discussed in the section on general indications for these operations in paralytic strabismus.

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[55]Knapp, H. *System of Diseases of the Eye.* Edited by Norris & Oliver, Vol. III, p. 865.

Tenotomy of More Than One Rectus Muscle.

In high degrees of strabismus the deviating eye may be turned in and up or down, or out and up or down. Tenotomy may be done on one muscle at one time, and upon another at a subsequent date. But if the deviation be fully sufficient to justify both tenotomies they may be made at a single operation. This is distinctly better when it is desirable to obtain a maximum effect. Any two adjoining recti muscles are readily reached through a single conjunctival opening. Suppose a case in which there is a fixed deviation inwards of 25 degrees, and upwards of 12 or 15 degrees.

The conjunctiva is raised between the insertions of the superior and internal recti, in such a way as to make a fold parallel to the corneal margin. This is snipped with the scissors making a cut in the conjunctiva, beginning about 2 mm. from the corneal margin, and extending 6 or 7 mm. in a direction radiating from the center of the cornea. Then the subconjunctival tissue is raised and snipped down

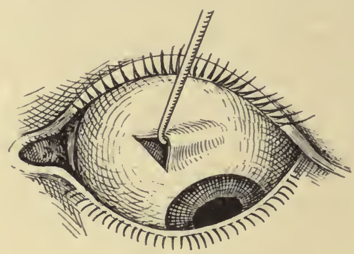

Fig. 305.

Tenotomy of the Internal Rectus and Superior Rectus at one Operation. Showing the Superior Rectus raised on the Hook for Subconjunctival Division.

to the sclera. With the points of the scissors alternately slightly opened and closed in close contact with the sclera, the tissue is tunnelled from the center of the conjunctival wound to a point slightly back of the upper end of the insertion of the internal rectus muscle, and then to a similar point just back of the nasal end of the insertion of the superior rectus, both points being within 5 mm. of the conjunctival incision. The tip of a rather large strabismus hook (one projecting 10 mm. from the shank) is then introduced through the conjunctival opening, carried back and down beneath the tendon of the internal rectus, and made prominent beneath the conjunctiva below the lower edge of the tendon. The tips of the scissors are introduced, and the tendon of the internus divided, as in ordinary subconjunctival tenotomy. The hook is then turned up and back under the tendon of the superior rectus, which is divided in the same way. Care should be taken to see that both tendons have been sufficiently divided. The eye is closed and treated as after an ordinary tenotomy.

Extensions of Tenotomy.

To do something more than simply divide the tendon or muscle, and so to produce a greater effect than could be obtained by simple tenotomy, and correct higher degrees of strabismus, has been an important undertaking of all who have practised the operative treatment of strabismus. The first efforts were in the direction of more severe crippling of the muscle tenotomized, by making the incision farther back, even in the belly of the muscle. Some early operators made very extensive separation of the eyeball from the tissues attached to it on the nasal side—so extensive that they may have involved the tendons of the superior and inferior recti. Franz[56] reported a case in which he thought he divided the tendon of the superior oblique, obtaining correction of upward inward deviation which had remained after tenotomy of the internus. But Duffin[57] shrewdly suggests that probably Franz divided the tendon of the superior rectus, which lay more in the direction of the incision described. In 1905 the writer[58] published the operation described below. It is based on the known participation of the superior and inferior recti muscles in producing convergence, referred to in the beginning of this chapter.

Tenotomy Extended to Secondary Adductors.

An ordinary tenotomy of the internal rectus is done by the open method. The conjunctival opening should be 8 or 10 mm. long and placed between the insertion of the internus and the corneal margin. From the upper end of the incision the tissues are tunnelled, to just back of the nasal end of the insertion of the superior rectus; by short snips of the scissors, or by a blunt dissection with the point of the closed scissors. In the same way the tissues are tunnelled from the lower end of the incision to just back of the nasal end of the insertion of the inferior rectus.

A rather large strabismus hook is passed upward and outward beneath the tendon of the superior rectus, until its tip shows beneath the conjunctiva at the temporal margin of the tendon, making the whole width of the tendon visible upon the hook. The scissors are then introduced, one blade in front of the tendon, the other beneath the hook behind the insertion, until the desired proportion of the width of the tendon is included between the blades. This part of the tendon is then snipped off. The same procedure is practised on the tendon of the inferior rectus muscle, *taking care to divide the same propor-*

[56]Franz, A. Operation for Strabismus. *London Medical Gazette*, XXVII, p. 40 and 197.

[57]Duffin, E. W. *Practical Remarks on the New Operation for the Cure of Strabismus or Squinting.* London, 1840.

[58]Jackson, E. Lateral Displacement of Tendon Insertions for the Cure of Strabismus. *Tr. Sec. on Ophth. A. M. A.*, 1905, p. 73.

tion of each tendon, unless there is also some vertical deviation to be corrected. The relations of the tendons to each other and to the conjunctival incision, and the parts of the insertions divided are shown in Fig. 306.

By this operation very little additional effect over the simple tenotomy is gained, unless fully half of the width of the superior and inferior tendons has been divided. This amount is what one may aim at in making the first cut. Then the position and movements of the eyes may be determined by inspection of the corneal reflexes, and by getting the patient to fix the finger tip carried to different parts of the field of fixation. If the effect produced still seems insufficient, the hook must be again introduced under each tendon beyond its temporal margin, and the proper proportion of the remaining width of

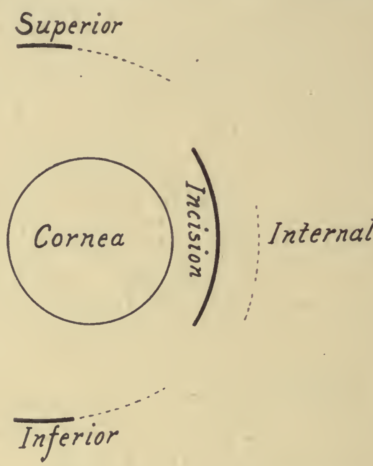

Fig. 306.

Extended Tenotomy of Internus. Relations of the conjunctival incision to the cornea and the insertions of the tendons. The parts of the insertions divided in the operation are indicated by dotted lines.

tendon divided, treating the two muscles alike. In no case is the whole width of the tendon to be divided. If this caution is observed the vertical movements of the eye will not be noticeably impaired even temporarily. The division of the superior and inferior tendons may safely be carried so far that there remains only a narrow band to hold the strabismus hook, two-thirds or three-fourths of the width of the tendon having been cut off.

For the correction of high convergent strabismus by tenotomy extended to the secondary adductors, the object aimed at should still be an under-correction. At the close of the operation there should still remain convergence one-fourth or one-sixth as great as at the beginning. For a convergence of 50 degrees one should aim to leave

about 10 degrees of convergence which will be gradually reduced before the eyes will reach their permanent condition of balance. A similar operation of complete tenotomy of the external and partial of the superior and inferior muscles may be practised, dividing the temporal portions of the latter. Generally this will be done in connection with advancement of the internus, for extended tenotomy, like simple tenotomy of the externus alone, gives a relatively slight effect.

Danger of Exophthalmos.

In view of the cases reported by the earlier writers, and mentioned even by writers of the present day, illustrating the danger of unsightly protrusion of the eyeball after tenotomy, it has been feared that exophthalmos would be likely to follow such extensive division of the tendons of the recti. But it does not. In the writer's cases on which such operations were practised, no consequent protrusion has been produced. The series is not a large one, but it is sufficient to show that protrusion is not usual. In no single case has any noticeable exophthalmos followed. The prominence of the eye has been measured before and after operation in several cases in which the lateral tendons have both been cut (one of them being advanced); and two-thirds or three-fourths of the superior and inferior tendons severed at the same operation, without any change in the prominence of the globe. Exophthalmos may occur after tenotomy, even so much as 2 or 3 mm. of protrusion. But in these cases there is evidence that the connective tissue structures other than the tendon have been extensively interfered with. The conclusion seems warranted that it is disturbance of the capsule, and not division of the tendons that causes the protrusion.

The cases yet submitted to extended tenotomy are too few to establish the amount of change in the direction of the eyes that may thus be obtained. But in moderate strabismus it seems to be almost double the effect obtainable by simple tenotomy; and in strabismus of very high degree many times greater than we expect of simple tenotomy. Whether any such effect would be produced by tenotomy of the internal rectus done at one time, and partial tenotomy of the superior and inferior recti done at another time, is doubtful. The latter operation, with stretching of the internus, has produced very little permanent effect.

A very undesirable effect of tenotomy, and one that has often occurred, is the subsequent deviation of the eye in the opposite direction. This is likely to occur where convergent squint has been fully corrected by an ordinary tenotomy at the time of operation. But it has not occurred after the extended tenotomies above referred to. Probably the later changes in the secondary adductors are in large

measure responsible for the subsequent divergence. But apparently when the relation of the secondary adductors is altered by the operation, a later change in them is less likely to occur.

Extensions of Tenotomy to the Capsule of Tenon.

These are operations which the writer believes should be generally replaced by advancement of the opposing recti. They are described here as of chiefly historical interest. They consist of extending the incisions from the tendon to neighboring connective tissue structures.

Of attempts to increase the influence of tenotomy by extending the incision to involve connective tissue structures other than the tendon, one of the best was described by Liebreich[58a] in 1866. Before dividing the tendon the scissors were carried between the conjunctiva and capsule back to the plica semilunaris; and then on toward the canthus, separating the plica and caruncle from the deeper structures connected with the eyeball. This was to prevent any sinking or disturbance of the caruncle by subsequent retraction of the tissues divided. Then after doing tenotomy, very much as done subconjunctivally by Critchett, the incision was extended vertically upward and downward, dividing the capsule to the extent necessary to produce the desired effect. By this operation Liebreich claimed to be able to correct about twice as much deviation as by tenotomy alone; and by one operation done on each eye, to cure the extreme cases of convergent strabismus.

Thread Operations to Increase the Effect of Tenotomy.

These are done to supplement the effect of tenotomy by controlling the position of the eye during the first few days of healing. The operation practised by Guérin, already described, may be regarded as the first thread operation. Operations for advancement of the muscles, with or without the capsule and related structures, have been spoken of as thread operations, but they are considered elsewhere. The especial technique of these supplementary operations was first brought out by Wilde, in the description previously quoted.

The thread is attached to some firm structure apart from the eye, to which the eyeball is thus anchored until the stitch begins to loosen. Graefe[59] reported a case in which he cut off both the internal and the external tendons; and without re-attaching either to the eyeball, anchored the globe in such a position that the cicatricial re-attachment of the tendons gave a satisfactory change in the direction of the visual axis. But his success does not seem to have been such as to lead him to persist in this operation, or to cause others to try it.

[58a]Liebreich, R. Nouveau Precédé de Strabotomie. *Gazette des Hôpitaux.* July 25, 1867.

[59]Graefe, A. Beitraege zur Lehre vom Schielen und von Schieloperation. *Arch. f. Ophthalmol.* iii. Pt. I, p. 177.

Knapp[60] passed the suture which anchored the eye through the lids. For convergent squint he secured a firm hold at the outer side of the cornea and carried the thread from within outward through the skin beyond the external canthus. For extreme divergent squint the thread was fixed at the nasal side of the cornea and passed through the skin near the inner canthus. But only the cases reported in his original paper have been placed on record.

Of recent years thread operations have been done to supplement the effect of tenotomy or advancement. They have been especially described and advocated by Gruening[61] and by Marple.[62] They are chiefly applied to cases of external strabismus. A stitch is firmly fixed in the conjunctiva at the nasal side of each cornea, after tenotomy of both external muscles. The ends of this suture are left long and secured over a bit of absorbent cotton on the bridge of the nose, coupling the eyes in a position of strong convergence, which is kept up for 24 hours beneath a binocular dressing. Care must be taken to see that the threads do not press upon the edges of the lids when normally closed.

The eye is commonly kept under a light dressing, which should be changed daily, and the eye cleansed.

OPERATIONS TO WEAKEN A RECTUS MUSCLE WITHOUT COMPLETELY CUTTING OFF ITS TENDON.

Partial Tenotomy.

This is done only for heterophoria and has been extensively practised and advocated by Stevens.[63] For his purposes he found the instruments in ordinary use for operations on the ocular muscles too clumsy, and devised more delicate ones.[64] The forceps end in fine teeth, projecting slightly to facilitate the seizing of firm tissue, like the sclera or the tendon close to the scleral insertion.

The scissors have their blades narrowed near their tips to facilitate their introduction through a small opening. The strabismus hook is smaller than those commonly employed, the shank ½ mm. in diameter and the hook projecting only 5 mm. from the line of the shank. In Stevens' operation the part of the tendon divided is the central portion directly at its insertion. The anatomic effect of tenotomy of the central part of the tendon, while the margins are left intact, is indicated diagrammatically in Fig. 307.

[60]Knapp, H. Erzielung grosser Wirkung bei den Schieloperationen. *Tr. Heidelberg Congress*, 1865.
[61]Gruening, E. The Operative Treatment of Divergent Strabismus. *Tr. Amer. Ophth. Soc.*, *Vol.* VI, p. 165.
[62]Marple. W. B. *Arch. of Ophth.*, 1903, p. 280.
[63]Stevens, G. T. *Functional Nervous Diseases.* New York, 1887.
[64]Stevens, G. T. *Motor Apparatus of the Eyes.* Philadelphia, 1906, p. 340.

The breadth of the insertion remains unaltered and the secondary functions of the muscle practically unchanged. On the other hand division of one side of the insertion as indicated in Fig. 308 produces some alteration in the secondary functions of the muscle.

For instance, division of the nasal half of the tendon of the superior rectus will permanently lessen its power to assist in the adduction of the eye. Division of the temporal part of its insertion will, on the other hand, tend to make the superior or the inferior rectus more of an adductor; and either of such partial divisions must affect the tendency of the muscle to cause intorsion or extorsion. Such a partial tenotomy was suggested by Savage[65] for the purpose of thus altering the plane of action of a muscle. Stevens originally desired to limit the effect of his operation to diminution of a single function of the muscle. His later operation of "extendo-contraction," intended to alter its action, will be described under class C.

Partial tenotomy of the central portion of the tendon of either of

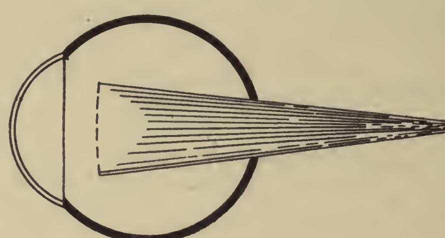

Fig. 307.

Effect of Partial Tenotomy where the Central Portion of the Insertion is Divided. The divided fibres are retracted.

the recti muscles is begun as the Snellen operation for complete tenotomy, care being taken to make but a very small opening in the conjunctiva, subconjunctival tissue and center of the tendon, at its insertion. The small strabismus hook is then passed through the opening and turned toward one-half of the tendon which is drawn on and raised slightly from the sclera. The fine-pointed scissors are then introduced through the conjunctival opening, with the tip of one blade behind the insertion, and in close contact with the sclera. The tip of the other blade is carried in front of the insertion, also in close contact with the sclera. What is deemed a sufficient portion, usually two-thirds or three-fourths of the half insertion, is then divided, care being taken not to sever the tendon all the way to its margin. The scissors are now withdrawn. The hook (with its handle and shank perpendicular to the surface of the sclera to cause the least disturbance of tissue) is turned so that the point passes beneath the other

[65] Savage, G. C. *Ophthalmic Myology.* Nashville, 1902, p. 160.

half of the tendon. This is similarly raised, and an equal proportion of this side of the tendon divided, with the same care not to divide the insertion all the way to the edge of the tendon. The scissors are then laid aside and the hook used to estimate the amount of insertion left undivided. First the strand at one edge of the tendon is drawn upon, then at the other edge. If the remaining strands show the same firm resistance as the whole tendon showed to start with, no perceptible effect will be produced by the operation, and more tissue must be divided. If the strand at one edge of the tendon shows less resistance than the other, it should be let alone and the other snipped until the resistance of the two appears to be just equal.

The resistance to the advancement of the hook toward the corneal margin should never be wholly overcome. When it is perceptibly lessened, the balance of the ocular muscles may be tested to determine if sufficient effect has yet been produced. If a greater effect is desirable, the hook is to be introduced again and more fibres divided at

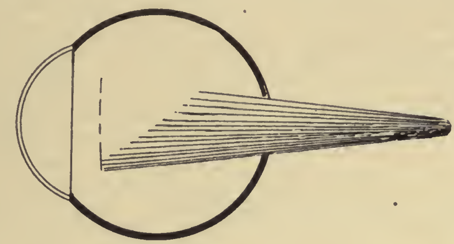

Fig. 308.

Partial Tenotomy where One Side of the Tendon is Freed from the Insertion and Retracted.

each edge of the tendon, care being exercised to keep the resistance of the edges equal. The effect of the operation can also be increased by rather forcible stretching of the edges left undivided. Where the effect produced is still insufficient, the operation can be carried over into a complete tenotomy.

Partial tenotomy by division of the central fibres was done by Smith,[66] by raising the tendon, entering the point of a keratome at its center, and pushing forward until enough fibres were severed. Partial division has also been practised by dividing both edges of the tendon at its insertion and leaving the central fibres intact. This method is less serviceable than division of the central portion. The firm central fibres do not give, and no perceptible effect is produced, until almost the whole width has been severed. Then there is a sudden giving way with perhaps the production of the effect of a com-

[66] Smith, E. Simple Method of Operating for Partial Tenotomy of the Recti Muscles. (Graduated Tenotomy.) *Arch. of Ophth.*, Vol. XXII, 1893, p. 16.

plete tenotomy. Then, too, the division of the lateral fibres causes a loss of the broad insertion of the tendon, which becomes attached to the eyeball by a narrow insertion, sacrificing accuracy and steadiness of fixation.

PARTIAL TENOTOMY BY DIVISION OF DIFFERENT FIBRES AT DIFFERENT DISTANCES FROM THE EYEBALL.

This has been proposed by Verhoeff,[67] and advocated by Todd,[68] and cases favorably influenced by the procedure were published by the latter. Verhoeff made the partial division of the tendon as shown in

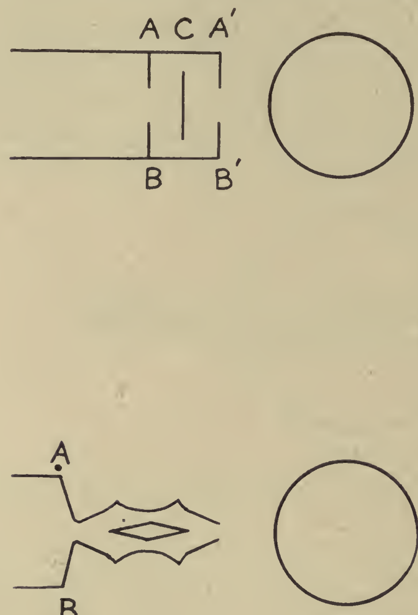

Fig. 309.

Partial Plastic Tenotomy of Verhoeff. The upper diagram shows the points A B, A′ B′, and C at which the tendon is partially divided. The lower diagram shows how the tendon becomes lengthened by giving way after the operation.

Fig. 309. The lateral fibres were divided at A B some millimeters back of the insertion, and at A′ B′ at the insertion. (Upper diagram). Between these the central fibres were divided, as shown at C. The effect to be produced by this operation is shown in the lower diagram. The tendon is elongated and weakened.

[67]Verhoeff, F. H. Eine graduelle plastische Tenotomie. *Klin. Monatsbl. f. Augenh.*, 1903, p. 234.

[68]Todd, F. C. A Method of Performing Tenotomy which Enables the Operator to Limit the Effect as Required. *Tr. Sec. on Ophth., Amer. Med. Assoc.*, 1907, p. 234.

Todd did not disturb the insertion of the muscle. But he divided one-half the fibres from one edge, a short distance from the insertion, and divided the other half of the fibres from the other edge of the tendon, a little farther back from the insertion. The same fibres may be divided at more than one point. The effect expected from such an operation is shown in Fig. 310.

The upper part of the figure shows the place for division of each part of the tendon in solid lines. The lower part shows the pulling apart of the divided fibres. The broken perpendicular lines are for purposes of comparison. The crosses indicate the same points of the tendon before and after operation, showing the elongation by their separation below.

After any of the operations for partial tenotomy it is customary simply to cleanse the eye, and leave it unbandaged. Quiet should be enjoined, and the use of a non-irritant collyrium prescribed. But the eyes may be used some from the first.

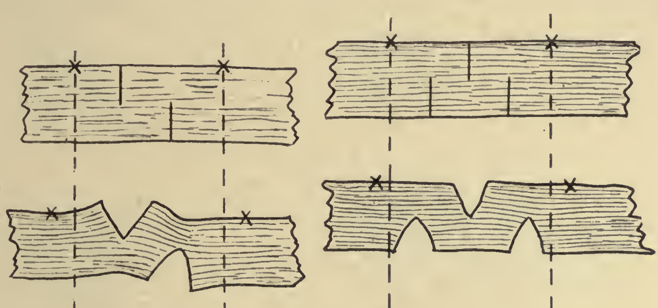

Fig. 310.

Partial Tenotomy by Lateral Incisions. (Todd.) The upper diagrams indicate two methods of placing the incisions. The lower diagrams show how lengthening of the tendon takes place. The greater distance between the crosses below shows the amount of lengthening.

Elongations of Tendons by Division and Suture.

This was proposed by Stephenson[69] in 1902, and by Landolt[70] in 1905. The general plan is to divide completely the tendon by an oblique or a step-like incision; and then to unite the ends by one or more sutures, in such a way as to leave the origin and insertion of the tendon farther apart. Different ways in which this may be accomplished are shown in Figs. 311 to 314.

These are open to the theoretical objection that there would be

[69]Stephenson, S. A short note on some cases of convergent strabismus treated by lengthening of the tendon of the internal rectus muscle. *Tr. Ophthal. Soc., United Kingdom*, Vol. XXII, p. 276.

[70]Landolt, E. Une Nouvelle Operation sur les Muscles Oculaires. L'allongement musculaire. *Arch. d'Opht.*, Jan., 1905.

danger of the bad effects of a lateral displacement of the tendon. But this danger may be avoided by a tongue-shaped division of the tendon, as suggested by Grimsdale.[71] See Fig. 313.

Stephenson[72] also suggested complete division of the tendon and the introduction of a suture between the retracted ends as shown in Fig. 314, the suture becoming the basis of scar tissue which should lengthen the tendon. Stephenson at the time of his original communication exhibited cases successfully operated on. But no extended careful studies of the actual effects of such operations for the lengthening of these tendons, either based on clinical or experimental data, have yet been published.

Tenotomy of the Oblique Muscles.

The oblique muscles are inserted on the posterior segment of the eyeball; the superior oblique passing beneath the superior rectus and the inferior oblique under the inferior rectus. It is quite impossible

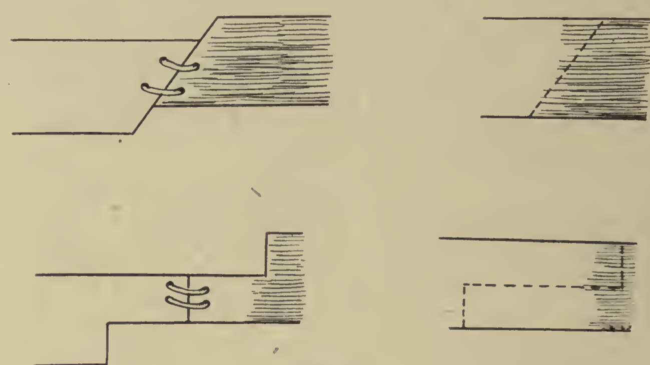

Fig. 311.
Stephenson's Method of Lengthening the Tendon by Step-like or Oblique Incision and Suturing.

accurately to divide the tendon of either of these muscles at its insertion, without such serious danger of a disturbance of related parts as to make the attempt unjustifiable. Tenotomy of these muscles is therefore a totally different operation from tenotomy of either of the recti muscles.

Tenotomy of the Inferior Oblique.

This muscle is most readily accessible at its origin; and is there least involved with other structures liable to be damaged by operation.

[71]Grimsdale, H. B. *Chief Operations of Ophthalmic Surgery.* London, 1904, p. 7.
[72]Stephenson, S. Some Recent Developments in the Surgical Treatment of Strabismus. *Lancet*, 1905, Vol. II, p. 883.

This was pointed out by Landolt,[73] who in 1885 suggested the operation of dividing it at this point. An incision 10 or 12 mm. long is made at the lower inner margin of the orbit, parallel to the edge of the orbit; and carried through the skin and the orbicularis muscle. Bleeding is stopped, and the edges of the incision retracted until the bone and the origin of the muscle are seen. The latter is to be recognized by its red color and the direction of its fibres passing obliquely outward, upward and backward. The muscle is gathered up with a strabismus hook, or seized by forceps; and divided as close to its origin as possible, either by scissors or a bistoury. The rolling up of the eye when the strabismus hook is drawn upon indicates that the muscle has been caught by it, as pointed out by Posey.[74]

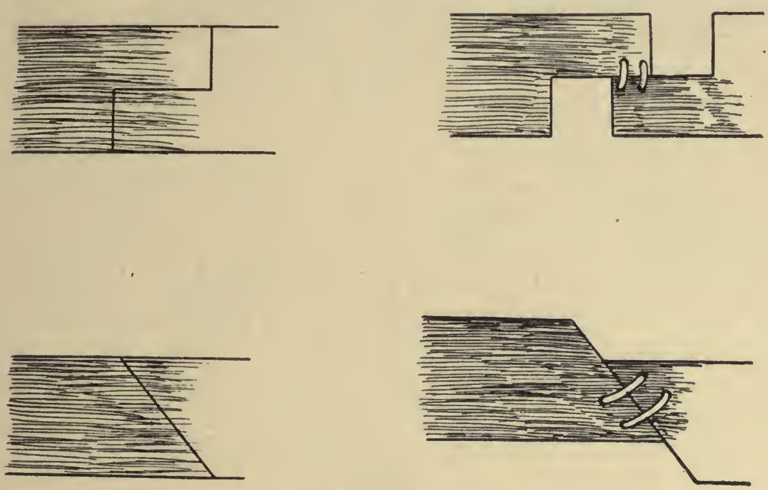

Fig. 312.
Modifications of Tendon Lengthening Suggested by Landolt.

Tenotomy of the Superior Oblique.

This can be done at the most superficial part of the tendon in the region of the pulley. Complete division may be justified to remedy the turning down and out of the eye after paralysis of the muscles supplied by the oculo-motor nerve; in which case the object would be, not merely to weaken the influence of this muscle on the position of the eyeball, but rather to destroy that influence altogether. This will be more certainly accomplished by excising a portion of the tendon. The writer has done the following operation on the cadaver, but not on the living patient.

The nasal portion of the upper lid is well raised by an elevator

[73]Landolt, E. La Ténotomie de l'oblique inférieur. *Arch. d'Ophtalmologie*, Vol. 5, p. 402.
[74]Posey, W. C. *Ophthalmic Record*, 1908, p. 346.

or strabismus hook, or a sharp hook held by the assistant. With the eye turned strongly down and out, the conjunctiva is seized and a radiating incision made, starting 10 mm. up and in from the corneal margin, and extending toward the pulley far enough to divide the retrotarsal fold up to where the tissues of the lid are attached to the orbital periosteum. The incision is made into the deeper tissues, and then extended by blunt dissection with the points of the closed scissors, with sponging and careful inspection of the structures laid bare, until the pulley and the tendon of the superior oblique are recognized. The exact position of the pulley can usually be recognized before

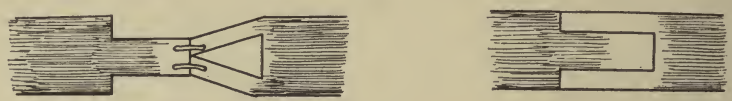

Fig. 313.
Grimsdale's Tongue-like Incision for Tendon Lengthening.

making the incision by the tip of the finger pressed into the upper inner angle of the orbit. The tendon is exposed from the pulley toward the eyeball (see Fig. 315) and divided.

The exposure of the pulley can also be accomplished by an incision from the skin surface at the upper inner angle of the orbit, as proposed by Dransart[75] for the grafting of the tendon of the oblique upon the external or inferior rectus.

Partial tenotomy could be done in this situation, or the tendon

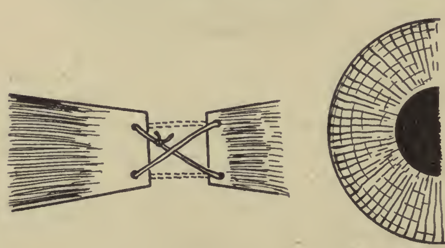

Fig. 314.
Stephenson's Method of Lengthening a Tendon by Dividing and Introducing a Silk Suture Between the Cut Ends.

can be divided quite obliquely, and the ends stitched together, as in one of Stephenson's operations for lengthening the tendon.

Complete abolition of the influence of the superior oblique may be secured by excising a part of the tendon 5 or 10 mm. in length extending from the pulley toward the eyeball.

[75]Dransart. De la suppléance du muscle grand oblique par le muscle droit externe et par le muscle droit inférieur, procédés opératoires. *Bulletins et Mémoires de la Société francaise d'Ophtalmologie.* 1907, p. 395.

B.—OPERATIONS INTENDED TO INCREASE THE INFLUENCE OF A MUSCLE OR MUSCLES ON THE MOVEMENTS OF THE EYE.

Advancement Operations.

These differ from each other as to whether the muscle is advanced upon the eyeball, along with the other tissues with which it is related (musculo-capsular advancement), or whether the attempt is made to partly separate the muscle from the related structures and bring it forward alone. They differ also as to whether the sutures used to secure reattachment are introduced simply into the episcleral tissue, or whether they are made to take hold of the firm tissues of the sclera, or the stump of the insertion of the advanced muscle. Then an indefinite variety of operations is produced by the use of one, two, three, or more sutures; and by the different ways in which these sutures have been placed or tied by different operators. The attempt to desig-

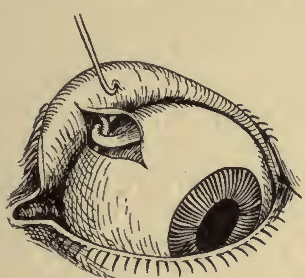

Fig. 315.
Method of Exposing Tendon of Superior Oblique at the Pulley for Tenotomy, Either Complete or Partial, Tendon Lengthening, or Resection.

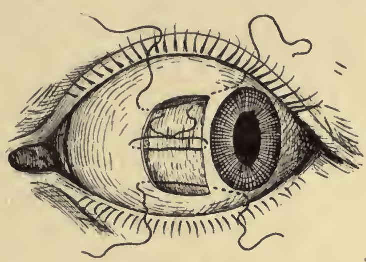

Fig. 316.
Critchett's Method of Advancement. Tissue excised and sutures introduced ready to tighten.

nate by the proposer's name each slight variation in the mode of performing an advancement operation is a source of confusion. The more valuable the operation, the more widely it is used or modified, the less definite is the meaning conveyed by such names. This is illustrated by the questions that have arisen as to how Graefe did a tenotomy, or what is a de Wecker advancement. Operations for the shortening of a muscle by exsection of a part of its tendon, or folding the tendon, "tendon-tucking," are in effect to be classed with advancements.

It is of great practical importance whether an advancement operation is done without other disturbance of the muscular attachments of the eyeball, leaving the advanced muscle to contend with the unhampered activity of its opponents; or whether by over-stretching or tenotomy, its chief opponents have been temporarily weakened or rendered powerless in a combined operation. It influences especially

the kind of anchorage that must be secured for the sutures and the probability of the first result remaining unchanged. But the general discussion of this matter is reserved for the sections on the general indications for and effects of different muscle operations.

Advancement of Muscle with Capsule.

Of the early operators for squint, probably all who had much experience had occasion to resort to advancement operations of some sort to redress the excessive effects of tenotomy. The first operation by Guérin has been described in the section dealing with the history of these operations. But the earliest form of advancement that remains today a valuable practical procedure, was first done to remedy a congenital divergent strabismus of high degree. It had been done by Critchett, but was described by Bader[76] in 1858. Both externi had been divided, and the eyes turned in by a thread across the nose. But at the end of a fortnight the divergence remained. An incision was made through the conjunctiva parallel to the inner edge of the cornea. "The conjunctiva, internal rectus, etc. were dissected off the sclerotic towards the inner canthus; and an oval piece of the flap being excised the wound was united by sutures, three in one eye and four in the other eye. The sutures had been drawn in before the incision was completed; they were removed in a week; no swelling or other bad result followed the operation; a very slight internal strabismus of either remains." This operation was subsequently described with more detail.[77]

Jessop[78] does not divide the insertion of the tendon until he has passed one suture through the center of the tendon, tied it tightly in a knot, and carried it through the episcleral tissue, bringing it out through the conjunctiva 1 mm. from the cornea. Then the tendon is cut away from the insertion; and additional sutures introduced at its upper and lower margins are anchored above and below the cornea.

The sutures were introduced by Critchett only into the episcleral tissue, and the externi being for the time rendered inefficient by previous tenotomy, the effect was all that was desired. But greater certainty of securing a definite change in the direction of the eye is to be had by passing the stitch into firm scleral tissue. The operation finally preferred by H. D. Noyes[79], after trial of many others, was essentially that described above, with these modifications. He introduced the sutures into the sclero-corneal junction using fine needles sharpened until they would penetrate as readily as a discission needle. Conjunc-

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[76]Bader, C. *Royal London Ophth. Hosp. Reports*, Vol. I, p. 254.
[77]Critchett.
[78]Jessop, W. H. *Manual of Ophthalmic Surgery and Medicine*, p. 360.
[79]Noyes, H. D. *Text-Book on Diseases of the Eye*. Ind. Ed., p. 171.

tiva, capsule and tendon were all grasped with fixation forceps, which were clamped upon them. The needle was then thrust through from conjunctival to scleral surface and the redundant tissue removed before drawing through the suture. After the three needles had thus been introduced into the flap, the sutures were drawn through this; and the needles made to penetrate the sclero-corneal tissue at the limbus. This is also the advancement operation described by Meller[80], except that he makes the track of the needles in the superficial scleral tissue parallel to the corneal margin.

Advancement of All Tissues with One Scleral Stitch.

This is the operation preferred by the writer for divergent strabismus of high degree. A curved incision in the conjunctiva and episcleral tissue is made, 10 mm. long and concave to the cornea. The flap toward the canthus is held up and dissected free from the sclera by snips of the scissors. The dissection is first to be made a little above or below the insertion of the internus, until one blade of the Prince advancement forceps can be slipped beneath the tendon, back from the insertion almost as far as it will be necessary to place the suture. The other blade of the forceps is pressed on the surface of the conjunctiva, so that the whole mass of tissue to be advanced is caught between the blades, which are closed upon it. With the flap thus held the insertion of the tendon, and all other adhesions of the flap to the globe, are divided by snips of the scissors. The flap can then be drawn forward into its desired relation with the eyeball; and the position of the suture necessary to retain it there, and the amount of redundant tissue to be removed, decided on.

The finest curved needle is then passed through the flap from the conjunctiva to the scleral surface, back of the blades of the advancement forceps and about 2 mm. above (or below) the center of the tendon. The needle is then passed into the sclera, parallel to the corneal margin and 1 mm. from it; in such a way as to take a firm hold in the sclera without passing through it. It should include one-fourth or one-third the thickness of the sclera; and the points of entrance and emergence should be 3 to 4 mm. apart. If at the first attempt the needle cuts or pulls out of the firm tissue, it should be introduced a little deeper and a little farther back from the cornea. The needle is then passed beneath the flap and through it from the sclera to the conjunctival surface, back of the blades of the forceps, opposite the original point of entry, and 2 mm. below (or above) the center of the tendon; that is 4 mm. from the first entrance. See Fig. 317. Any tissue that will be clearly redundant, including that held in the forceps,

[80] Meller, J. *Ophthalmic Surgery.* (Amer. Tr.) p. 86.

should now be excised, the flap drawn forward, and the suture tied. If after this there still remains redundant tissue this may then be trimmed away.

Generally the above suture is all that is necessary, and upon it is to be placed the chief reliance for the success of the advancement. If, however, there appears a tendency of the conjunctival wound to gape near its upper and lower angles; or if the tissue seems to be much dragged toward the central suture, with a tendency to narrow the new attachment of the tendon to the eyeball, additional sutures may be placed above and below the first one.

To introduce such a suture thrust one blade of the forceps beneath the flap, and raise the tissue from the sclera. The needle may be rather larger than for the first stitch and carrying thicker silk. It is thrust from the conjunctival to the scleral surface of the flap; then carried under the conjunctiva above (or below) the cornea, close to

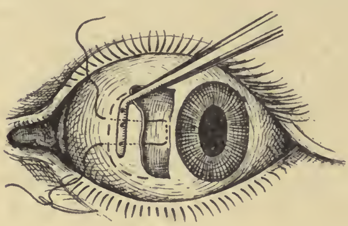

Fig. 317.

Advancement with Single Scleral Stitch. Tissue held by forceps and scleral stitch placed ready to cut away tissue at the broken line.

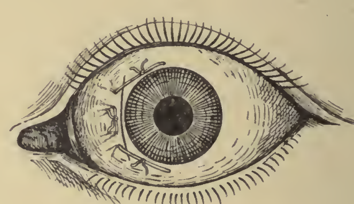

Fig. 318.

Advancement with Scleral Stitch in Centre, and Superficial Stitches above and below, at completion of operation.

its margin, almost to its vertical meridian, but without any attempt to enter the sclera. This suture should be so placed that beside closing the conjunctival wound it will tend to spread the end of the tendon and secure as broad an attachment as possible for it in its new position. The position of the sutures at the close of the operation is shown in Fig. 318.

The after treatment consists in keeping both eyes closed for the first day with a light dressing, cleansing the eye once or twice daily, and continuing the dressing on the operated eye for four or five days. The sutures should remain from four to eight days.

Early removal of the stitches is indicated when the effect seems likely to be excessive, or when profuse conjunctival discharge develops. Advancement of the external, superior or inferior rectus muscle may be performed in the same manner. But for the superior and inferior muscles, in most cases, one of the operations to be presently described, dealing with the tendon alone, will be preferred.

Essentially the same operation has been described by Jocqs[81]; and Motais[82] has used two such sutures, one to secure the upper and one for the lower portion of the tendon.

Advancement with Partial Isolation of Tendon.

This was first described by Agnew[83]. He made a horizontal incision beginning 2 mm. from the nasal margin of the cornea, and extending to the semilunar fold. This was carried down to the sclera and muscle to be advanced. A strabismus hook, with an eye drilled in its free extremity, and armed with waxed silk, was then swept beneath the upper edge of the tendon, going far enough back to include every straggling band; and the ligature so introduced was tied close to the insertion in the sclera. A free tenotomy was done on the opposing external rectus muscle. The tendon to be advanced was raised by the ligature placed around it, and was divided at its insertion. Two retentive sutures were now introduced through the tendon far enough back to produce the advancement desired, and to take a firm hold rather deep in the muscle. The needles were passed from the conjunctival to the scleral surface of the tissues, one near the upper, the other near the lower margin of the tendon. After these were placed, the end of the tendon included in the ligature was cut off. The ligature served to hold the tendon, as can be more conveniently done by the Prince's advancement forceps.

Then each needle was carried beneath the conjunctiva, above or below the cornea respectively, so as to take a firm hold in the sclera and emerge about 2 mm. from the corneal margin in the vertical meridian. Both sutures were drawn up before either was tied.

In doing this operation Carter[84] used cat-gut retentive sutures, which were left in permanently.

In 1878 Landolt[85] wrote his first paper on advancement. His operation deals directly with the tendon alone, although he claims it is in effect an advancement of all structures intimately related to the muscle. Its relation to de Wecker's musculo-capsular advancement is readily traced, but it would now be regarded rather as an advancement of the insertion of the tendon. It is the prototype of many of the recent modifications of advancement.

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[81]Jocqs, R. Strabisme de 50 degrés. Absence de Convergence. Guérison par l'Avancement Musculaire. *La Clin. Ophtal.*, 1904, p. 206.

[82]Motais. Nouveau procédé de Suture dans l'avancement musculaire. *Bulletins et Mémoires de la Société francaise d'Ophtalmologie*, 1906.

[83]Agnew, C. R. A Method of Operating for Divergent Squint. *Tr. Amer. Ophth. Soc.*, 1866, p. 31.

[84]Carter, R. B. *Practical Treatise on Diseases of the Eye.* Edited by Green, p. 438.

[85]Landolt, E. L'Avancement Musculaire. *Compte rendu de sa Clinique pour L'Année*, 1878, p. 16.

A semi-circular flap of the conjunctiva only, down to the subconjunctival tissue and capsule of Tenon, is dissected up over the insertion of the muscle to be advanced. See Fig. 319.

The anterior extremity of this flap begins almost at the corneal margin. It is broad enough to expose freely the whole width of the tendon. The flap is turned back, and the strabismus hook passed beneath the tendon, which is raised on it. Or to secure the whole width of the tendon and to give better access to it a second hook may be passed beneath it from the opposite side. The hook is confided to the assistant. Two sutures are then passed from the conjunctival toward the scleral surface, through the capsule and tendon. These are placed at the junction of the middle and lateral thirds of the width of the tendon, and far enough back to secure the necessary advancement of

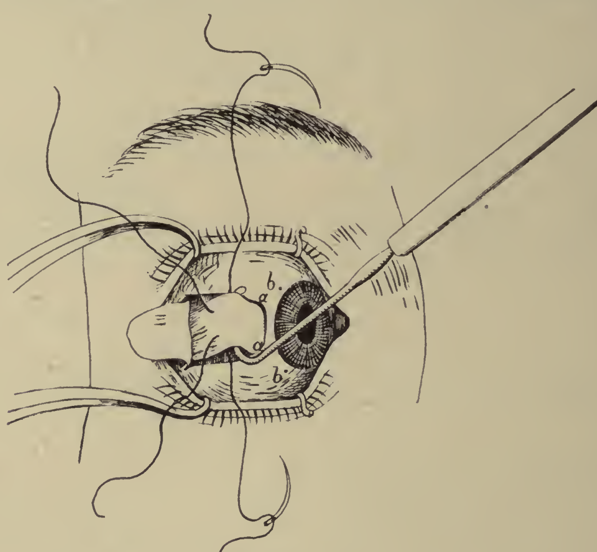

Fig. 319.

Advancement with Partial Isolation of the Tendon. Method of Landolt. Showing the sutures placed in the tendon; but not yet introduced beneath the conjunctiva at *a*, to be brought out at *b*, above and below the cornea.

the insertion. These sutures are brought out beneath the edges of the tendon, as shown in Fig. 319.

The four threads may now be taken in the left hand, the tendon drawn away from the eyeball, the blade of the scissors slipped beneath it, and the tendon divided in front of the position of the threads. If the effect of the operation is to be but slight the tendon is divided at its insertion. If a greater advancement is desired the tendon may be divided farther back towards the sutures and the stump so left cut off at the insertion.

The placing of the sutures in their position of anchorage is the most delicate part of the operation. The point of the needle is introduced at a (or a′) and carried to b (or b′) through the firm episcleral tissue at the junction of the conjunctiva and cornea. In children, by using a sharp needle, Landolt[86] claims that this is not difficult; because the conjunctival tissue is firm and the sclera is soft. But in adults in whom the sclera has become hard and the conjunctiva thin and loose, it is more difficult to secure a firm anchorage. When it is not secured at the first attempt, the needle may be again entered under the conjunctiva and an additional mass of tissue included until a firm hold is secured.

The threads having been introduced, the eyeball is brought into proper position and the muscle drawn forward to the margin of the

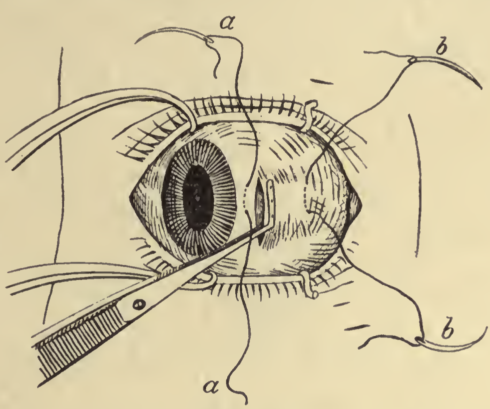

Fig. 320.

Advancement with Pulley Stitch. (Prince.) Stitches placed, *a* pulley, and *b* tendon suture.

cornea with the fixation forceps. The threads are then tightened, care being taken to secure the same tension of each suture. To ensure this they may be drawn upon alternately; and one tied with a temporary knot until the right degree of tension is reached, when the permanent knots are to be tied. To avoid confusion Landolt makes one suture of black, the other of white silk.

Even where but one has been operated on, both eyes are kept bandaged for 5 or 6 days, being cleansed and dressed but once in the 24 hours. The stitches are removed at the end of 5 or 6 days. The condition to be aimed at is an over-correction, during the period that the stitches remain in.

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[86] Landolt, E. Die Chirurgischen Eingriffe bei Störungen des Bewegungsapparates der Augen. *Graefe-Saemisch Handbuch der Gesamten Augenheilkunde.* 2nd Ed., pt. 91, p. 249.

Advancement with Anchor Stitch.

The first operation of this sort was described by Prince[87]. The anchor or pulley suture is introduced 1 mm. from the corneal margin deep enough to take hold of the firm scleral tissue. The conjunctiva and subjacent tissue are divided parallel to the corneal margin, as shown in Fig. 320.

One branch of the advancement forceps is introduced beneath the tendon and the other closed upon it, securing the edge of the conjunctiva, after which the insertion of the tendon is divided. The loop suture *b* is then introduced by the needles at each end, which are passed beneath the tendon from its scleral surface out through the conjunctiva. The location of this suture is governed by the amount of advancement required. The tissues grasped by the forceps are then excised to about 2 mm. in front of the suture *b*. The suture *a* is tied over one end of the suture *b*, becoming a pulley. The suture *b* as shown in Fig. 321 is then drawn upon, and tied in a bowknot.

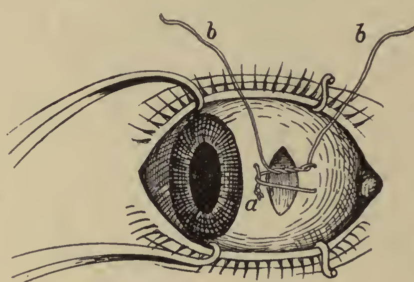

Fig. 321.

Pulley Advancement (Prince) with Tissue Excised. Pulley stitch *a* tied, and tendon stitch *b* ready to tighten.

Subsequently the tension of this suture may be increased or diminished, if such change is required to secure the effect aimed at. It is then tied in a permanent knot.

Two stitches placed somewhat like those of Prince have been used by Hulen[88], who, however ties them differently. He places each thread double; and uses one pair of the sutures to draw the eye into position, while the other pair are tied together. The first may be left in position temporarily; and tied for a better adjustment if necessary, the other stitch being cut and removed.

Williams' single suture advancement begins with a radiating (horizontal) incision over the middle of the tendon to be advanced, which is extended from near the cornea to near the canthus. The tendon or

[87]Prince, A. E. Operation for the Advancement of the Rectus with the Capsule. *Ophth. Review*, Vol. 6, 1887, p. 249.

[88]Hulen, V. H. The Advancement Operation in Squint. *Tr. Sec. on Ophth., Amer. Med. Assn.*, 1910, p. 225.

muscle thus laid bare is raised and isolated on the strabismus hook. The suture is introduced beginning near the corneal margin rather lower than the edge of the tendon. It is carried beneath the conjunctiva, brought out of the wound, and passed back and forth through the tendon parallel to the corneal margin, after which it is brought under the conjunctiva to the point opposite its original entrance. Grimsdale and Brewerton[89] suggest that it should be dipped into firm tissue at its point of first entering the conjunctiva, and also just before its final emerging. The suture thus placed is shown in Fig. 322. Loops of suture are left on either side of the tendon, which are drawn out of the way until the tendon has been separated from the sclera. Then the parts are drawn into the desired position and the suture tightened and tied. The tying of the suture tends to close the conjunctival wound, and bring folds of conjunctiva over to the cornea. These folds tend to protect the cornea from the suture and disappear when the

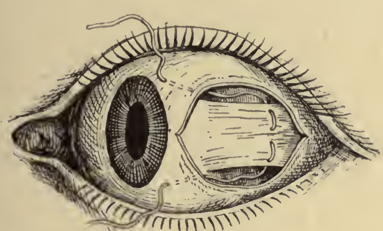

Fig. 322.
Single Stitch Advancement of Williams. Tendon exposed and suture placed before the insertion of the tendon has been divided.

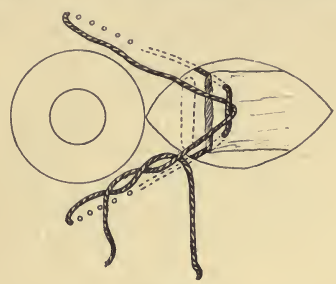

Fig. 323.
Single Stitch Advancement. (Beard.) Suture placed and ready to tighten. Dotted portion embedded in sclera. Single broken line shows insertion from which tendon has been divided.

latter is removed. The conjunctival wound is closed with a suture. The sutures are removed about the eighth day.

The operation first described by Beard[90] seems to have been worked out independently by Ferguson,[91] and Howe.[92] The conjunctiva is raised in a vertical fold back of the insertion of the muscle and snipped over the center of the tendon. The incision thus begun is carried forward to the corneal margin and through the episcleral tissue, forming a furrow "whose bottom is the naked sclera and along which the cut tendon is to slide."

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[89]Grimsdale and Brewerton. *Text Book of Ophthalmic Operations*, p. 33.
[90]Beard, C. H. Advancement with but a Single Suture. *Amer. Jour. of Ophth.*, 1889, p. 74.
[91]Ferguson, H. L. A Stitch for the Adjustment of the Ocular Muscles. *Tr. Ophth. Soc., United Kingdom*, Vol. XVII, p. 336.
[92]Howe, L. *The Muscles of the Eye*, Vol. II, p. 354.

The tendon is raised on a medium sized strabismus hook, inserted beneath it as close as possible to the insertion. The hook is held by an assistant until the stitch is placed. A fine, perfectly sharp, half-curved needle is threaded on each end of a No. 1 braided black silk suture. This has been boiled in equal parts of paraffin and vaselin. Both needles are passed through the tendon from the conjunctival to the scleral surface, as shown in Fig. 323, the distance back from the end of the tendon being determined by the extent of the advancement desired. The upper needle is carried beneath the conjunctiva, above the cornea, for some distance; and then made to enter the firm scleral tissue, through which it passes to a point 4 or 5 mm. above the limbus at or beyond the vertical meridian, where it is made to emerge. The lower needle is carried below the cornea in a similar way. During the procedure the eye may be fixed by grasping the tendon firmly at its insertion.

The part of the suture crossing the tendon has been left loose up to this time. The upper end of the suture is then passed under it, and the two ends brought together. Both loops of the suture are carefully held out of the way while the tendon is raised and divided as far from the insertion as the case may require. The stump thus left is cut off even with the sclera. The loop of suture across the tendon is drawn tight, the assistant rotates the eye into proper position, and the operator ties the suture. It may be tied in a bow-knot and readjusted after 24 hours; or tied with a fixed knot at once.

Howe[93] has done an operation resembling this in the main, but instead of entering the scleral tissue for anchorage he causes the upper suture to include the nearer margin of the superior rectus tendon near the insertion; and the lower anchorage similarly to include a portion of the inferior rectus tendon.

The suture is allowed to remain 6 to 9 days, the eye being dressed and the dressing changed every 48 hours. For the first two days both eyes should be bandaged and absolute rest in bed insisted on. Beard[94] accompanies the advancement by a partial tenotomy of the opposing muscle. Where the suture is first tied in a bow-knot the ends should be made fast near the canthus by a bit of adhesive plaster.

Advancement With Splitting of the Tendon.

This operation was described by Valude[95] in 1896. He exposes the tendon by a vertical incision and introduces two sutures; one at the junction of the upper end and second quarter of the tendon; the other

[93] Howe, L. *The Muscles of the Eye*, Vol. II, p. 351.
[94] Beard, C. H. *Ophthalmic Surgery*, p. 179.
[95] Valude. Nouveau procédé d'avancement musculaire, *Annales d'Oculistique*, Vol. 116, p. 112.

at the junction of the lower and third quarter. The tendon is then divided at its insertion, and split horizontally 6 or 8 mm. back from the insertion. One-half of the tendon is then sutured above, the other half below the cornea, as shown in Fig. 324. See also the folding operations of Colburn and Magnani.

Special Forms of Suture for Muscular Advancement.

These constitute the most important features of a large number of modifications of muscular advancement. Argyll-Robertson,[96] after dividing and isolating the tendon, in much the same manner as Williams and Beard, used a double-armed waxed silk suture, one end of which was passed in and out through the tendon or muscle parallel to the corneal margin, and a sufficient distance back from the insertion to give the desired advancement. The needle was then passed beneath the conjunctiva, around the cornea, well beyond its opposite margin. The second needle was then similarly passed in and out through the conjunctiva around the other half of the cornea to emerge near the

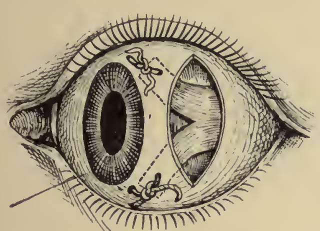

Fig. 324.
Advancement with Splitting of Tendon. (Valude.) Showing tendon sutured in new position, conjunctival wound not yet closed.

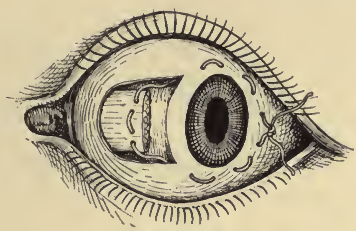

Fig. 325.
Advancement with Suture Carried Around the Cornea. (Argyll-Robertson.)

first needle. See Fig. 325. After excision of so much of the tendon as it was desirable to remove, the parts were brought into apposition and the suture tied. This suture was allowed to remain 4 or 5 days. This carrying of the suture around the cornea has also been tried by Cogan.[97] Howe,[98] also, after anchoring the stitches by catching his sutures through a small loop near the center of the tendons of the superior rectus and the inferior rectus, carried these ends around to the external rectus, which was also caught in the suture that was tied over it.

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[96] Argyll-Robertson, D. On a Modification of the Ordinary Method of Operating for Advancement of the Tendon of a Rectus Muscle. *Brit. Med. Jour.*, 1891, Vol. II, p. 471.

[97] Cogan, J. E. Observations on Methods of Advancement. *Ophthalmic Record*, 1906, p. 357.

[98] Howe, L. *The Muscles of the Eye*, Vol. II, p. 355.

Melville Black[99] in 1895 suggested the following: Two fine curved needles are threaded with No. 3 silk, and the two ends of each suture tied together (or needle may be double threaded), so as to make a closed loop. The sutures are made fast to the eyeball by passing each needle through the conjunctiva, and deep enough to get a "good bite" into the sclera, close to the cornea, as shown in Fig. 326, A.

After passing through the ocular tissue the needle is slipped through the loop and the latter drawn tight. This gives a firm anchorage to the stitch. The tendon is then isolated and raised on the strabismus hook, and each suture is passed through the tendon from the scleral to the conjunctival surface near the corresponding margin of the tendon. The tendon is then cut off at the proper distance in front of the sutures, and the stump cleanly dissected from the insertion. The two double ligatures are then tied over the tendon, as shown in Fig. 326, B.

It is of historical interest to note that Bajardi,[100] among various modifications of the sutures, proposed one in which they should pass

Fig. 326.

Advancement with Two Sutures. (Black.) A shows the upper suture anchored in the sclera, the lower suture passed through the sclera and through the loop, but not yet drawn tight. B shows the two sutures passed through the flap, drawn up and tied.

through the lids, and be tied over a shot or bead upon the skin surface. Swanzy[101] and de Schweinitz[102] use two sutures each enclosing one-half the breadth of the tendon. These sutures are brought forward to emerge from the conjunctiva near the vertical meridian above and below the cornea. Sauvineau[103] has used a similar stitch for the Motais advancement.

The arrangement of the sutures adopted by Wootton[104] is shown

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[99] Black, M. New Method of Tying the Sutures in Advancement of the Ocular Muscles. *Arch. of Ophth.*, Vol. XXIV, p. 375.

[100] Bajardi, P. Qualche Modificazioni al Metodo di Avanzamento Capsulo-muscolare nelle Operazion per Strabismo. Turin, 1896.

[101] Swanzy, R. H. *Handbook of Diseases of the Eye and Their Treatment.* Chapter XVIII.

[102] de Schweinitz, G. E. *Diseases of the Eye.* Sixth Ed., p. 869.

[103] Delord and Revel. *L'Ophtalmologie Provinciale.* March 1908.

[104] Wootton, H. W. Some Advancements without Tenotomies; A Description of the Operation Employed. *Arch. of Ophth.*, Vol. XXX, p. 229.

in Fig. 327, which represents the sutures entirely placed, ready for closure of the wound. Wootton isolates the tendon and permits the conjunctiva to retract. Then he introduces the muscle end of the suture, passing the needle first through the conjunctiva about 1 mm. from the cut edge. The tendon is then cut close to the points penetrated by the suture; after which the corneal end of each suture is introduced, no conjunctiva being sacrificed.

Thomson[105] has modified this operation by introducing the threads only through the margins of the tendon before dividing the tendon 1 mm. in front of the stitches. The muscle is then drawn forward by traction on these stitches and the middle suture introduced, first into the center of the tendon and then superficially in the sclera at the corneal margin. The anterior or limbus ends of the lateral sutures are then placed and the sutures tied, the middle one first. After the

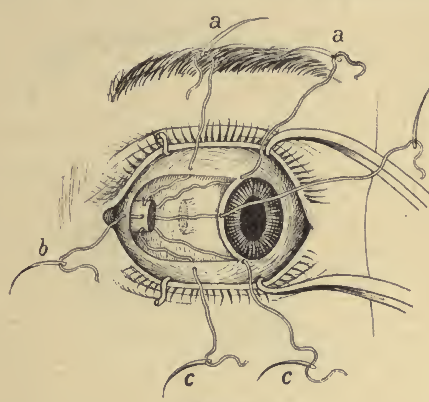

Fig. 327.
Advancement by Wootton's Method. Stitches placed and tendon cut off; a, upper, b, middle, and c, lower stitch.

tendon has thus been advanced the free ends of the sutures are used to suture the conjunctiva.

On account of the tendency of finer threads to cut through the tissues, Worth[106] employs a black silk, marked No. 24, and used for sewing boots. This he boils in water, to sterilize it and remove superfluous coloring matter, dries, and then drops it in a mixture of paraffin or wax three parts and vaselin five parts. The silk drawn from the boiling mixture is wound on a brass reel, and kept in a sterilized glass jar for immediate use. This suture, when threaded in a sterilized needle, is twisted, so that the two thicknesses make a single cord. The conjunctival incision is made convex to the cornea to favor retraction

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[105]Thomson, J. J. Recent Changes in Technique of Some Operations on the Eye and Adnexa. *Ophth. Rec.*, March, 1905, p. 118.
[106]Worth, C. *Squint*, First Am. Ed., p. 206.

of the tissues. The advancement forceps are introduced, and the tendon and retracted conjunctiva clamped together. The needle of one suture is then passed from conjunctival to scleral surface at A. It is brought out through the same tissues at B, so as to include one-fourth the width of the tendon. In the same way the second stitch is carried in at A′ and brought out at B′. The suture is then tied, forming a loop A′B′C, which includes one-fourth of the width of the tendon. The end of the suture carrying the needle is then passed through the tissues from the conjunctival to the scleral surface at D; and carried forward beneath the tendon to the limbus, where it is passed through the tough "circumcorneal fibrous tissue" and is brought out at G. In the same way the first suture entered at A is tied to include one-fourth of the tendon and the needle passed beneath and through the circumcorneal tissue at G.

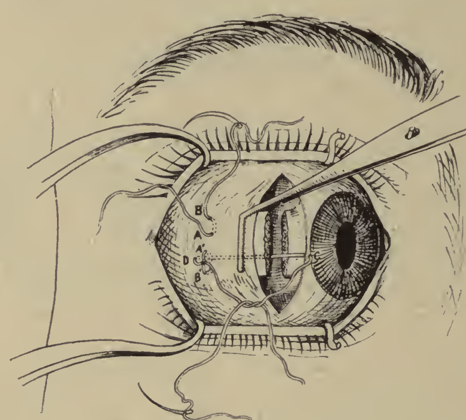

Fig. 328.

Advancement Sutures as Placed by Worth. A B shows suture introduced first time through tendon. A′ B′ D C suture passed second time through tendon and through limbus ready to tie.

The portion of the tendon and conjunctiva grasped by the forceps is then excised. The sutures are tied in loose knot at H, and the tendon drawn forward. When the parts have been properly brought into apposition and redundant tissue removed, the sutures are tightened. The patient, if a young child, is kept in bed with both eyes bandaged for four days. An older patient is allowed to have the unoperated eye opened, wearing his glasses; which have paper stuck on them, so as to leave only a vertical slit in the middle to look through. The stitches are removed and the dressings omitted on the eighth day.

The stitch devised by Stevenson[107] is intended, like that of Worth,

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[107]Stevenson, M. D. Description of an Advancement Suture. *Sec. on Ophth., Amer. Med. Assoc.*, 1905, p. 174.

to catch the tendon in a cross loop; but to accomplish it by a single stitch. A black braided silk suture, No. 8, is threaded to a needle near each end. After a primary incision the conjunctiva and capsule are pushed well back, and clamped with the tendon in the advancement forceps. The tendon is divided. One of the needles is passed from the conjunctival surface through capsule and tendon at the junction of the upper and middle thirds of the latter; and then passed from the scleral surface outward through the same structures at the upper margin of the tendon. It is again entered at the first point of entrance forming to loop *a*. See Fig. 329.

The needle is then carried beneath the conjunctiva almost to the edge of the cornea where it is passed through scleral tissue. The needle at the other end of the suture is similarly used entering at the

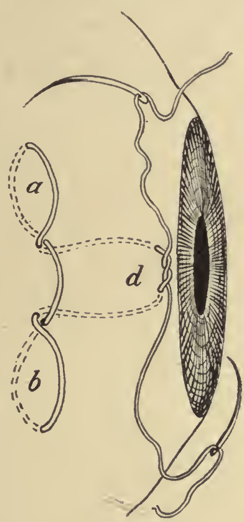

Fig. 329.

Advancement Stitch of Stevenson. Loops *a* and *b* include the tendon. Suture ready to tie at *a*. Buried portions of suture shown in broken lines.

junction of the lower and middle third and forming the loop *b*. When completely placed the suture consists of two loops, *a* and *b*, connected by a central cross piece lying on the conjunctiva. The parts are brought into proper position, the suture tightened and tied at *d*, between the two points of scleral anchorage.

The simple stitch suggested by Verhoeff[108] is illustrated in Fig. 330. The tendon is exposed through a vertical incision 3.5 mm. from the cornea, raised on a strabismus hook and isolated. It is then seized with the advancement forceps near the insertion. A double

[108] Verhoeff, F. H. A Secure Stitch for Advancement Operations. *Ophth. Record*, 1901, p. 514.

armed silk suture is used. It is first introduced into the sclera for 2.5 mm. as shown in A, one-half to one mm. from the corneal margin. Then each needle is introduced at the point of exit of the suture, and carried horizontally 2.5 mm. towards the insertion of the tendon as shown in B. The tendon is then divided at its insertion and the two needles passed through it sufficiently far back, C. The tendon is then brought forward with the forceps, the eyeball rotated into position, and the suture tightened, D. A sufficient portion of the tendon grasped in the forceps is excised and the conjunctiva brought together by two superficial sutures.

Lea,[109] after exposing the tendon and clamping it with conjunctiva and capsule with the advancement forceps, divides it at its insertion. He then takes his suture of "not too fine silk," which has been boiled in wax, and passes it through the conjunctiva and sub-conjunctival

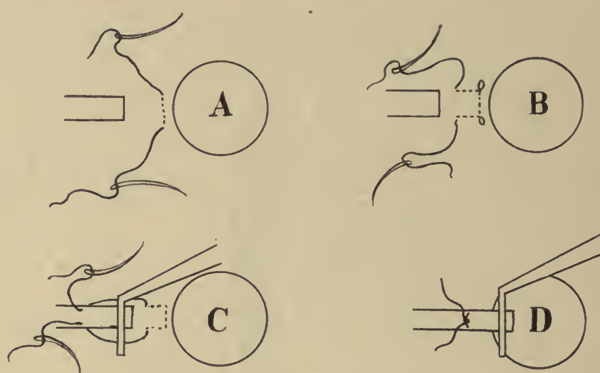

Fig. 330.

Advancement Stitch of Verhoeff Showing Different Stages. The dotted lines indicate the part buried in the sclera.

tissues near the cornea, making a running stitch which begins a little higher than the upper, and ends a little lower than the lower, margin of the tendon. The needle is then passed through conjunctiva and tendon in the same kind of stitch beginning below as shown in Fig. 331. The end of the tendon with the clamped tissues is cut off, and the stitch tightened.

The suture used by Oliver[110] is double-armed. It is first carried beneath the isolated tendon or muscle. One needle is passed from the scleral surface out at the junction of the lower and middle thirds. The other is made to emerge at the junction of the middle and upper thirds. The tendon thus secured is freed from the sclera. Each needle is then carried beneath the conjunctiva and into the anterior layer of

[109] Lea, J. H. Personal Communication to the Editor.

[110] Oliver, C. A. Single Stitch Operation for the Advancement of the Exterior Ocular Muscles. *Ophthalmology*, Jan., 1906, p. 219.

the sclera 1 or 2 mm. from the limbus. The needles are then carried beneath the conjunctiva and brought out at points corresponding with the underlying sclero-conjunctival stitches.

In 1864 H. D. Noyes[111] had used a somewhat similar stitch by which he says "the conjunctiva is drawn up over the cornea like the mouth of a purse, and the muscle is pulled forward." But in his later writings he does not refer to this method.

An elaborate stitch devised by Cogan is illustrated in Fig. 332. One needle of a double-armed suture is first entered at A and passed from the conjunctival surface through capsule and muscle, carried forward to B, where it enters the sclera, and brought out at C. The other needle of the same suture is entered at D, passing from con-

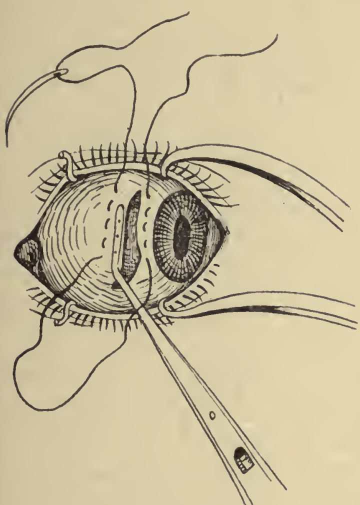

Fig. 331.
Advancement Stitch of Lea. The broken lines represent the suture running in and out of the tissues.

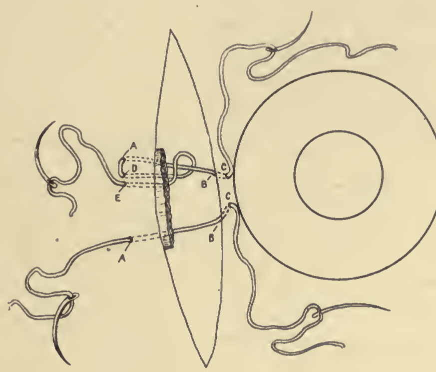

Fig. 332.
Advancement Stitch of Cogan. Both ends of the upper suture have been introduced so that it is ready to tie. Only the first needle of the lower suture has been passed.

junctival to scleral surface, and is carried out under, and back over, the portion of the same suture running from A to B. It is then brought through from the scleral to the conjunctival surface at E. The second suture is similarly introduced near the other edge of the tendon.

Advancement With Folding of the Tendon.

Although various writers have proposed operations in which the

[111]Noyes, H. D. *Amer. Med. Times*, 1864, Vol. I, p. 244 and 267.

tendon was folded without any cutting thereof, the excision of the fold thus made is usually mentioned as a trifling modification of the operation; and it is often recommended as being followed by less swelling of the parts and more rapid return to normal. No sharp distinction can be made between operations of this class and the forms of advancement already described. A distinction is often made between folding the tendon forward to the corneal margin, "folding forward," and making the fold entirely behind its insertion, "tendon tucking" or shortening. Yet after doing the latter operation some operators prefer to stitch the loop so formed to the sclera in advance of the insertion. We will here consider, first, operations in which the fold in the tendon is made without special apparatus.

Tendon Folding by Suture.

The oldest of these operations is the so-called capsular advancement of de Wecker.[112] An incision is made over its insertion, and the tendon isolated and raised with de Wecker's double advancement hook. A suture threaded to three needles is then taken, the central needle is passed through the center of the tendon from the scleral surface outward; and each of the other needles is passed beneath the conjunctiva to a point in the vertical meridian of the eyeball 3 or 4 mm. back from the corneal margin as shown in Fig. 333. The thread is then cut in the middle, making two sutures. These two sutures can be tied separately in the ordinary way, the two ends of the lower suture together. But de Wecker chose to tie the corneal end of the upper suture to the muscle end of the lower suture; and the muscle end of the upper suture to the corneal end of the lower suture. In this way he made in effect a single crossed suture, making it impossible to draw the lower part any more or any less tense than the upper. He hoped thus to avoid drawing the tendon of a lateral muscle either upward or downward and thus changing its plane of action. Subsequently de Wecker practised his capsular advancement with division of the tendon in some cases, and also employed a stitch resembling that suggested by Savage.

What he calls a tendino-capsular advancement was described by Knapp[113] in 1886. In general character it is essentially the operation of de Wecker. But the sutures employed are placed as in the advancement done by Critchett. Knapp[114] says: "The operation in fact is the same as Critchett's, without excision of a piece of tendon."

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[112]DeWecker, L. De l'Avancement Musculaire au Moyen du Double Fil. *Annales d'Oculistique*. Tome 70, p. 225.

[113]Knapp, H. Advancement of Tenon's Capsule in Strabismus. *Tr. Amer. Ophth. Soc.*, Vol. IV, p. 345.

[114]Knapp, H. Operations Usually Performed in Eye Surgery. *System of Diseases of the Eye*. Norris and Oliver, Vol. III, p. 877.

The operation of muscle shortening described by Lagleyze[115] in 1891 is done as follows: The conjunctival incision is made concave to the corneal margin, in advance of the tendon insertion, and a flap of conjunctiva covering the insertion is excised. The tendon is exposed and isolated on two strabismus hooks. A double-armed suture is introduced by passing both needles from the scleral surface outward through the tendon or muscle and conjunctiva sufficiently far back from the insertion; one needle being passed 1 mm. from each margin of the tendon or muscle. The needles are then entered beneath the conjunctival flap adjoining the cornea, and superficially into the sclera, and brought out at the corneal margin, as shown in Fig. 334. The tightening of the suture folds the tendon forward almost to the corneal

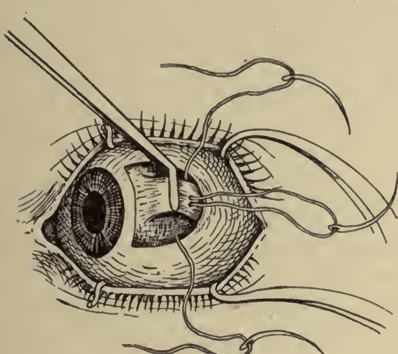

Fig. 333.
Advancement by the Method of de Wecker Showing Introduction of Sutures.

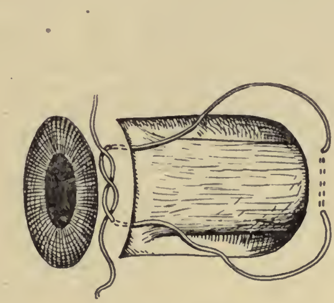

Fig. 334.
Folding of Tendon as done by Lagleyze.

limbus. The suture is allowed to remain ten days to secure firm union.

An operation for shortening an ocular muscle by folding the tendon on itself by simple suture was described by Savage[116] in 1893. A vertical incision is made in the conjunctiva 3 mm. posterior to the insertion of the tendon, and a little longer than the tendon is wide. From the lower extremity of this, a horizontal incision 6 mm. long is made near to the lower border of the muscle. The triangular flap is dissected up and held aside. A puncture is made in the capsule at the lower border of the tendon, a strabismus hook introduced beneath the tendon and a second puncture that permits the tip of the hook to appear above the upper margin of the tendon. A suture double-armed is introduced thus: The tendon being raised by the strabismus hook,

[115] Lagleyze, P. Traitement du Strabisme par le raccourcissement des Muscles Droits. *Arch. d'Ophtal.*, XXII, p. 668.

[116] Savage, G. C. Muscle Shortening versus Muscle Advancement. *Ophth. Record*, March, 1893.

and the muscle by forceps, each needle is passed through capsule and muscle from the outer to the scleral surface; as far back as it is desired to include the tendon or muscle in the fold. One needle is passed in the upper half, the other in the lower half of the tendon, so as to include fully one-fourth the width of the muscle between the punctures. Each needle is then passed through the insertion of the tendon from behind forwards, opposite the point at which it enters the muscle; and brought out through the conjunctiva directly over the insertion. The suture is then tightened and tied, bringing the included portions of the tendon (and muscle) into a loop. To the extent of the loop it shortens the distance between the origin and insertion of the muscle, without changing the position of the insertion. The loop is covered by the conjunctival flap and the stitch allowed to remain 4 to 6 days. The knuckle of the muscle thus formed is left to undergo absorption. A very similar operation was subsequently described by Brand.[117]

Woodruff[118] uses in tendon-tucking a stitch like that devised by Worth, except that it does not include the conjunctiva, which is dissected from the deeper parts as far back as possible, held aside for the operation, and afterward closed by separate suture.

Suffa[119] has folded the tendon by the following somewhat elaborate stitch: After exposing and isolating the tendon a double-armed suture is laid across the tendon at A, sufficiently far back from the insertion to give the required amount of shortening. The needle attached to the upper end of the suture is introduced beneath the tendon, which is made to pierce the scleral surface at B, at the junction of the upper and second quarters of the width of the tendon, in front of the suture A. It is then carried over the suture to C, where the needle again pierces the tendon, from the conjunctival to the scleral surface, and is carried beneath the tendon to its insertion, where it pierces, emerging at D. The lower end of the suture is similarly carried through at the junction of the lower and third quarters of the tendon, back, through and forward to the insertion. The tendon is folded by tightening the sutures. The conjunctival opening is closed by a superficial suture on either side, being allowed to gape over the knot in the tendon suture.

Bourgeois[120] after exposing and isolating the tendon introduces sutures, scrapes the surfaces of the muscles that are to be folded to-

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[117]Brand. Ueber Muskelvorlagerung. *Centralbl. f. p. Augenh.*, 1902, p. 298.

[118]Woodruff, H. W. Shortening of an Ocular Muscle by Tucking. *Jour. Ophth. and Oto-Laryngol*, April, 1910.

[119]Suffa, G. A. An Original and Absolutely Reliable Suture for Tucking or Shortening an Ocular Muscle. *Arch. of Ophth.*, Vol. XXXVIII, p. 254.

[120]Bourgeois. Avancement capsulo-musculaire par doublement et adossement du muscle. *Bull. et Mémoires de la Société francaise d'Ophtalmol.*, 1906.

gether, and raises the loop on a spatula 4 or 5 mm. broad until it is drawn forward by the sutures.

Stevens[121] excised a triangle of the tendon, its base at the insertion, its apex in the median line of the tendon, sufficiently far back from the insertion. The cut edges of the tendon are then brought forward by sutures; the central portion of the tendon being most advanced or shortened, and the margins remaining undisturbed.

On account of the thickening caused by the loop of tendon formed by various folding operations, which he has practised since 1886, Colburn[122] prefers a combination of section and folding of the tendon. He opens the conjunctiva anterior to the insertion and dissects it backward, making a tongue-shaped flap. A central partial tenotomy is then made, leaving a narrow band of fibres on each side. The end of the tendon then takes the shape of K K, in Fig. 336. The

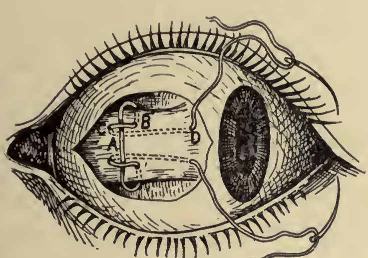

Fig. 335.
Stitch for Folding Tendon, proposed by Suffa. Both ends introduced.

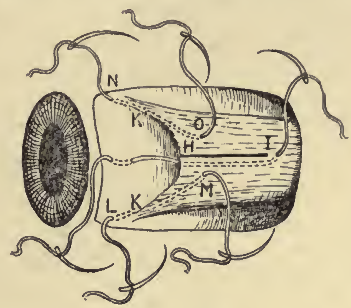

Fig. 336.
Advancement by Folding after Partial Tenotomy and Splitting of the Tendon. (Colburn.)

tendon is split at the center along H I, as far as it is desired to shorten it. A suture is passed through the center of the tendon entering near I from the conjunctival to the scleral surface, carried beneath the tendon from the site of its insertion beyond H, made to enter the sclera, and brought out near the corneal margin. Two additional sutures, L M and N O, are introduced in the two halves of the split tendon. The central stitch is tightened first, then the others.

An ingenious method of folding the tendon after splitting it is described by Magnani.[122a] An incision slightly concave toward the cornea is made in the conjunctiva a little in front of, and somewhat longer than, the insertion of the tendon. The tendon is then exposed, iso-

[121]Stevens, G. T. Tendon Resection and Tendon Contraction for Shortening the Recti Muscles. *New York Med. Jour.*, March, 1889.

[122]Colburn, J. E. Muscle Tucking; Report of Cases and Conclusions. *Ophth. Record*, 1902, p. 197.

[122a]Magnani, C. Nuovo metodo per l'avanzamento capsulo-muscolare *Annali di Ottalmologia*, XXXVII, 1908.

lated for a sufficient distance back of the insertion, and split longitudinally in the middle, without dividing the insertion. Five sutures are introduced as shown in Fig. 337. Two of these, A and B, enclose each one-half of the split tendon in its loop and are then carried beneath the conjunctiva, the free ends emerging near the vertical meridian of the eyeball. Next to each of these comes a suture, C and D, which penetrates the corresponding half of the tendon near its insertion, and also sufficiently far back to aid in the folding of the tissues. The fifth suture, E, is placed in the median line of the tendon, piercing it back of the slit, and taking a firm hold on tissue at the seat of the tendon insertion before it is brought out through the conjunctiva near the limbus. The tightening of these threads produces a folding of the split portions of the tendon, with drawing forward and shortening of the muscle as a whole. The threads are removed on the sixth day.

Trousseau,[123] under the name "capsular ligature," has described

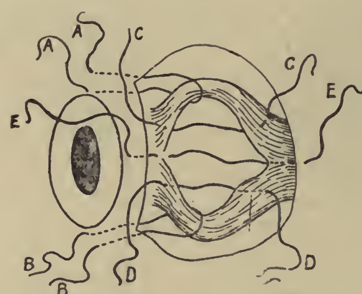

Fig. 337.

Folding Forward of the Split Tendon. (Magnani.) The sutures are introduced ready to tighten, beginning with E.

a very simple, but he claims, effective form of advancement. Without opening the conjunctiva the tendon is grasped through the conjunctiva and raised from the eyeball with forceps. A half-curved needle is then introduced near the sclero-corneal junction, and through the insertion of the tendon. The needle passes beneath the ocular surface of the tendon a sufficient distance, and the point is brought out through the tendon and conjunctiva. The suture is then drawn upon sufficiently and tied. The suture is allowed to remain 6 to 12 days, being removed earlier if the effect seems likely to be excessive. Removal of the thread on the second or third day was followed by diminution of the effect to the extent of 5 to 8 degrees. Trousseau has used this operation like other forms of advancement.

[123]Trousseau, A. La Ligature Capsulaire dans l'Opération du Strabisme. *Annales d'Oculistique*, Jan., 1903, p. 17.

It is one that might be used to supplement a tenotomy producing insufficient effect.

Folding the Tendon With Special Instruments.

Various surgeons have devised operations for folding the tendon of the recti muscles with the aid of special instruments upon which the facility and exactness of these operations largely depend. These instruments include some form of triple strabismus hook, like that of Clark; forms of tendon tucker, like those of Green and Levinsohn, and the clamp for securing a loop of tendon, as proposed by Briggs.

Tendon Folding With the Triple Hook.

This was first described by Maxwell.[124] After exposure the tendon is taken up on a strabismus hook, and its side attachments divided by scissors, cutting backward along each side of the tendon. An instrument having two parallel fixed hooks, and a central movable hook to slide between them, is placed so that the central hook takes up the tendon. The central hook has been protruded to do this. It is then drawn in, its motion being controlled by a screw and indicated on a millimeter scale. When a sufficient loop of the tendon has been drawn between the two fixed hooks, a suture with a needle at each end is passed through the doubled tendon from behind forwards as close above the fixed hooks as possible. The hooks are then removed, the suture tightened with a temporary knot, and the effect tested. If this is too great or insufficient, another suture may be introduced and the first removed. When the right amount of shortening is secured a permanent knot is tied. A loop of tendon now projects from the wound. A double-armed suture is passed through this loop, and the needles carried beneath the conjunctiva sufficiently far back to draw the loop smooth and flat. The latter suture may be taken out in one or two days; but the first suture should be left for a week.

The form of hook described by Clark[125] is shown in Fig. 338. The central movable hook placed between two fixed hooks can be made to project, or can be drawn up by means of a milled screw and rachet. The handle is made detachable, so that in the absence of an assistant it may be removed, leaving the hooks as a clamp holding the tendon in position for introducing the sutures. Clark prefers to include as much of the capsule as possible in the fold. Three stitches are used, the lateral sutures interlocking with the central one. Clark

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[124]Maxwell, P. W. Precision in Squint Operations. *Brit. Med. Jour.*, 1896, Vol. II, p. 819.

[125]Clark, C. F. A Double Hook for Use in Advancement Operations. *Sec. on Ophth., Amer. Med. Assoc.*, 1900, p. 164.

at first suggested excision of the loop, but later stitched it down anterior to the tendon insertion.

Bruns[126] modified the instrument of Clark by giving the central movable hook a longer bearing in the milled screw collar. To secure the loop he uses a double suture which transfixes the center of the tendon. The needle being cut off, each half of the suture is tied around the corresponding half of the tendon. Bruns also had a hole drilled in the tip of the movable hook. After securing the tendon a ligature is threaded through this hole. As the hook is withdrawn it carries the thread through the loop. This is armed with a needle at each end, and these needles are carried beneath the conjunctiva, one towards the upper, the other towards the lower corneal margin. They are brought out at the limbus near the vertical diameter. One end is then carried back to the posterior flap of the conjunctiva and passed

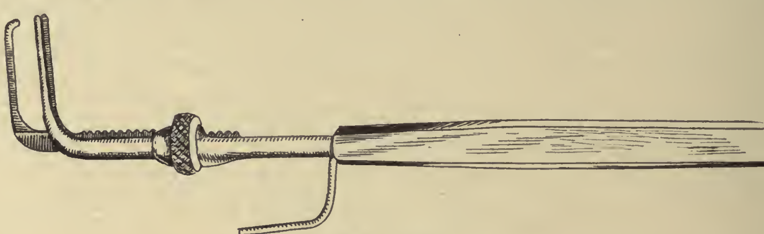

Fig. 338.
Clark's Double Hook for Advancement by Folding the Tendon.

through it. The tying of the two ends together, and the tightening of the loop of the suture, spreads the tendon flat upon the sclera towards the cornea, and brings forward the posterior flap of the conjunctiva. This "guy suture" becomes slack and should be removed in a week. The sutures in the tendon can be left for months or permanently.

Within a few months Stroschein[127] has described another form of triple strabismus hook, the central hook movable by a sliding button.

Advancement with Tendon Tuckers.

Quite a different method, and a correspondingly different instrument for folding the tendon, were devised by Greene.[128] These are illustrated in Fig. 339. The instrument consists of forceps handles with one straight and one angular blade, each carrying a tip or tine perpendicular to its general direction. After exposure and iso-

[126] Bruns, H. D. A Method of Advancing the Tendons of Recti Muscles. *Ophth. Rec.*, 1904, p. 267.

[127] Stroschein, E. Eine sehr einfache Methode der Vorlagerung. *Klin. Monatsbl. f. Augenh.*, Jan., 1910, p. 43.

[128] Greene, D. M. Correction of Divergent Strabismus by a New Method and a New Instrument. *Ophth. Rec.*, 1899, p. 462.

lation of the tendon the tip of the straight blade is introduced beneath it while the tip of the angular blade rests upon the insertion. Pressing the blades together causes the one tip to pass the other, forming a fold, the extent of which can be fixed by the set screw. When, by this folding, the eye is brought into proper position, the fold is made permanent by passing each needle of a double-armed suture through the three thicknesses of the folded tendon, from the scleral side outward, and tightening the ligature with a permanent knot.

A slightly different instrument for the same purpose was de-

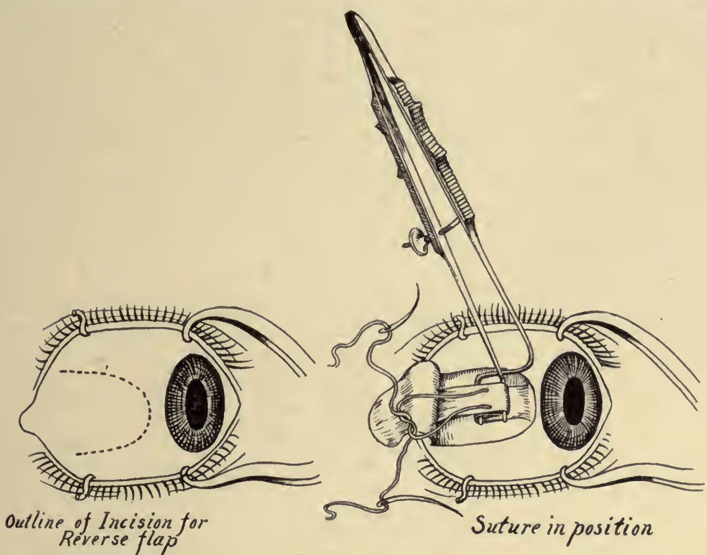

Fig. 339.
Greene's Instrument and Operation for Folding the Tendon.

vised by Todd.[129] The instrument consists essentially of two prongs each hooked to prevent the tendon from sliding off, their position being controlled by a screw. After exposure and isolation of the tendon by dissecting up a conjunctival flap, one prong is introduced beneath the tendon as shown in Fig. 340. By use of the screw the prongs are made to move past each other, causing a double folding of the tendon. When this folding is deemed sufficient to bring the eye into proper position, two catgut sutures are introduced and tied. Then a silk suture, double-armed, is introduced. One end is carried through the conjunctival flap, as shown in Fig. 340. The other end is carried through the folded tendon just back of the catgut suture, and then forward under the conjunctiva, into firm scleral tissue,

[129]Todd, F. C. A Secure Advancement Operation Performed with the Aid of a New Tendon Tucker. *Ophth. Rec.*, 1902, p. 73.

emerging above the cornea. The tendon tucker is then removed, and a corresponding suture introduced through the lower portion of the flap, tendon and loop, emerging below the cornea. The silk sutures are used to regulate the amount of effect produced. They may be left tied with a temporary knot until the next day, when a readjustment can be made and a permanent knot tied.

A still more elaborate instrument for grasping the tendon and folding it has been suggested by Levinsohn.[130] It is shown in Fig. 341. The exposed tendon is grasped at two points, sufficiently far apart, by closing the short handles that operate the jaws of the instrument; and this hold on the tendon is retained by the spring catches. By bringing together the long handles the closed jaws are made to pass each other, causing a folding of the tendon to any desired extent, when the instrument may be fixed by the toothed catch at the end of the long handle.

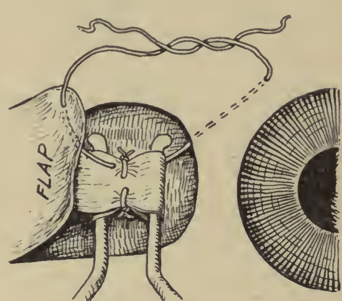

Fig. 340.

Todd's Operation for Tendon Tucking. Showing loop of tendon held on prongs of instrument, cat-gut sutures introduced, and placing of regulating suture for upper edge of tendon.

Use of Tendon Clamp.

A quite different method of forming and retaining the fold in the tendon has been worked out by Briggs.[131] He fixes the looped tissue by clamping it with a ring of silver wire. The special instruments required are shown in Fig. 342. They include a strabismus hook small enough to go through the ring, forceps for clamping the ring, rings of silver wire of appropriate size, and wire scissors for cutting the ring when the time comes to remove it. The ring of wire is an oval, with a major axis of 5 mm. and a minor axis 2 mm.

A small opening is made in the conjunctiva and capsule at one edge of the tendon to be folded, 2 to 4 mm. behind its insertion, ac-

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[130]Levinsohn, G. Beiträge zur Vorlagerung von Augenmuskeln. *Klin. Monatsbl. f. Augenh.*, Sept., 1909, p. 299.

[131]Briggs, H. H. A New Method of Tendon Shortening. *Tr. Amer. Acad. Ophth. and Oto-Laryngol.*, 1908, p. 212.

cording to the amount of shortening intended. An ordinary strabismus hook is passed beneath the tendon, and held by an assistant. The ring is held in the clamp forceps over the structures to be looped, and the small strabismus hook passed through the ring is substituted for the one first used to raise the tendon. By the small hook the tendon with overlying conjunctiva and capsule is drawn up through the ring to the desired degree; and the jaws of the clamp forceps forcibly approximated, closing the ring tightly on the included tissues. If a great deviation is to be corrected, after drawing the tissues slightly through the ring the conjunctiva may be incised, and only the tendon shortened to the desired degree. If a large loop of tendon is thus included, the greater part of it should be cut off, leaving only enough to prevent retraction of the cut ends. The ring quickly becomes covered by the edema of surrounding tissues, and within twenty-four hours the strangulated tissues become white and begin to atrophy. They should be excised on removal of the ring, at the end

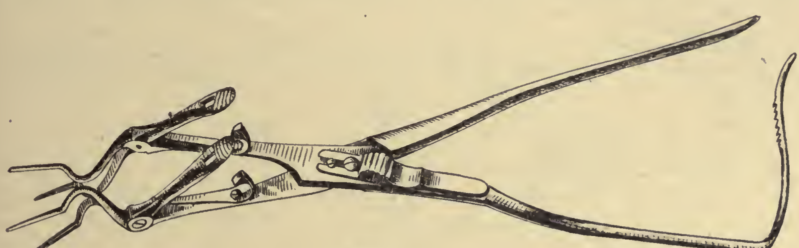

Fig. 341.
Levinsohn's Instrument for Seizing and Folding the Tendon. Shown with the jaws opened.

of ten or fourteen days. The ring is removed by cutting it with the special wire scissors at each end.

Shortening a Muscle with Section or Resection.

In the advancement operations that seek to bring the insertion of one of the recti muscles closer to the cornea the tendon is divided; and often part of the tendon, with or without other tissues, is excised. In shortening by folding the tendon, the loop formed by the operation may be cut away. But we here consider those operations in which the tendon is always divided and lapped, or a portion excised; and the muscle thus shortened is reattached to the original seat of insertion. The first and still one of the best operations of this kind was proposed by J. F. Noyes.[132] Two years later substantially the same operation was published by Driver.[133] See Fig. 343.

[132]Noyes, J. F. A New Method of Operating for Strabismus. *Tr. Amer. Ophth. Soc.*, Vol. II, p. 273.
[133]Driver. Eine Modification der Schieloperation. *Klin. Monatsbl. f. Augenh.*, 1876, p. 133.

The conjunctiva is opened by a horizontal incision directly over the tendon, and long enough to expose a sufficient portion of it. The tendon is raised on the strabismus hook, seized by the advancement forceps; and divided far enough back of the insertion to allow the other portion of the tendon to be pulled beneath the stump and secured to it by sutures. The amount of shortening measured in millimeters should equal the deviation to be corrected. The two surfaces of the tendon which are brought together should be freshened by a knife. Two stitches are used. One is introduced through the conjunctiva, and then from beneath through the overlapping portion of the tendon near one margin. The second stitch is similarly introduced near the other

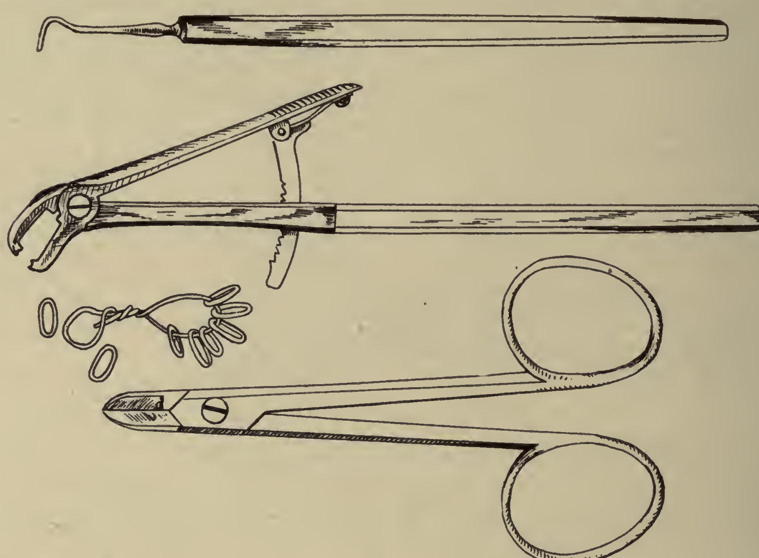

Fig. 342.

Briggs' Instruments for Tendon Shortening by use of Silver Wire Clamp. From above downwards: Small strabismus hook to slip through wire ring, forceps for clamping ring, silver wire rings, special scissors for cutting silver wire.

margin of the tendon. Callan[134] has removed as much as 12 mm. from the external rectus, correcting thereby a convergence of 35 degrees.

In doing shortening by resection of the muscle, Reese[135] uses three sutures. The middle one of No. 9 silk, double-armed, is passed from scleral to conjunctival surface of the tendon back of the forceps; one needle 1 mm. above and the other 1 mm. below the center of the tendon, the needles also piercing the edge of the more superficial tis-

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[134]Callan, P. A. Strabismus from the Operative Standpoint. *Tr. Amer. Ophth. Soc.*, Vol. XI, p. 668.

[135]Weeks, J. E. *A Treatise on Diseases of the Eye*, p. 891.

sue. The side sutures, of No. 5 silk, are passed through the edges of the tendon from the conjunctival surface toward the scleral, a little farther back than the central suture. The tendon is cut off at least two millimeters in front of the sutures; and all the sutures are made fast by passing the needles through the 2 mm. stump of tendon at the insertion. The central suture is left in ten days, the others 48 hours. The different steps of the operation are illustrated in Fig. 344.

Schweigger[136] after exposure of the tendon isolated it upon two strabismus hooks, and placed beneath the tendon a little spring gauge carrying two hooks. This gauge was set so that the two hooks were separated as many millimeters as the muscle was to be shortened, and held apart by the comparatively fixed tension of the spiral spring. A needle attached to one suture was passed under the upper margin of the muscle and pushed through below the middle of the muscle from the scleral to the conjunctival surface. The needle attached to the other suture was passed from the lower margin of the muscle and pushed

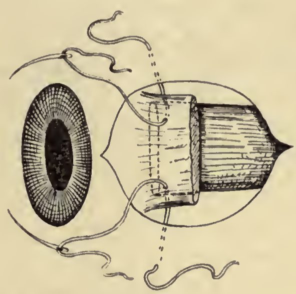

Fig. 343.

Advancement with Resection of the Tendon as done by J. F. Noyes. Showing sutures introduced. The broken line indicates end of muscle slipped under stump.

through above the middle. These sutures were tied, each including more than one-half the width of the muscle, the central portion being included in both loops.

The muscle being thus secured the tendon was divided near, but not directly at, its insertion; and a sufficient portion of it excised to permit neat apposition of the two cut ends. Each of the ligatures was then carried through the stump of the tendon at its insertion, made to dip into firm scleral tissue, and tied. The muscle at the point of ligation was thus brought forward to the scleral insertion.

Müller[137] is careful to leave a 2 mm. stump of tendon at the insertion, and to amputate the muscle 2 mm. in front of the muscle su-

[136]Schweigger, S. The Results of the Operation for Strabismus. *Arch. of Ophthal.*, 1895, p. 8.

[137]Müller. Beiträge zur operativen Augenheilkunde. *Klin. Monatsbl. f. Augenh.*, XXXI, p. 118.

tures. He uses a third suture at the center of the tendon if there is much tension. These sutures are buried and left permanently.

General Considerations Regarding Advancement Operations.

A large part of the difficulties regarding advancement operations arise from the character of the tissues dealt with. The conjunctiva and subconjunctival tissue being extremely loose, easily dragged away from their normal position and readily cut by sutures, offer a poor

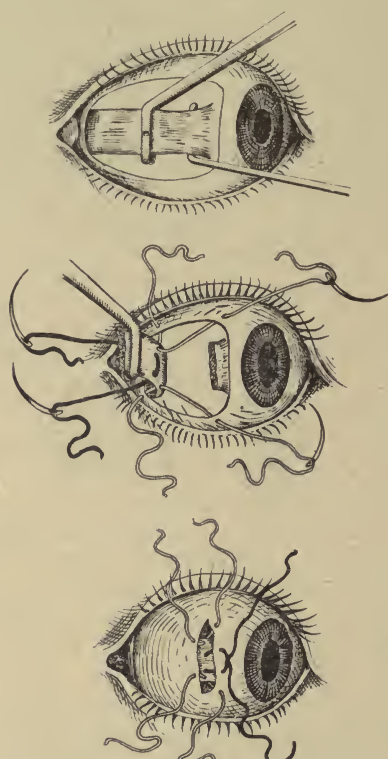

Fig. 344.

Advancement with Resection as Done by Reese. Above: Tendon isolated held by advancement forceps with groove to show middle of tendon. Middle: Sutures passed through tendon which is held back. Below: Sutures in place ready to tie.

anchorage for supporting sutures. That is the reason that many operators from the days of de Wecker have sought to include a great breadth of the conjunctiva in the sutures. This is why Argyll-Robertson, Howe, and Cogan have proposed to run the conjunctival sutures entirely around the cornea, making the whole of the firm attachment of the conjunctiva at the limbus available for support.

On the other hand the firm tissue of the sclera offers an ideal an-

chorage for sutures. The objection to its use is the risk of perforating the whole thickness of the sclera and opening a channel for infection to the interior of the eyeball. In attempting to place sutures in the sclera the needles used should be fine and sharp. The eyeball should be firmly held so that the needle will be passed just where it is intended. Even with care and in competent hands it is likely that complete perforation of the sclera is not very rare. Cogan, passing sutures in pigs' eyes, found the sclera perforated in half of them. H. D. Noyes[138] speaking of the needles making the deep anchorage at the sclero-corneal junction wrote, "I have seen the points sometimes appear in the anterior chamber, but this is, of course, too deep." Serious harm from such perforation, however, is barely mentioned in the literature of the subject, and must be very unusual. From the margin of the clear cornea it is 2 or 3 mm. back to the canal of Schlemm and the ciliary region. The sclero-corneal junction is the thickest part of the sclera. Although the introduction of sutures here is not free from risk, the danger is not great.

The tendons of the ocular muscles themselves are thin and not adapted to offer any great resistance. To one who knows of them only through reading and work upon the hardened cadaver, it is always a matter of surprise to find they are so thin and non-resistant especially in the direction of their fibres. A suture can very readily cut out; and the muscle itself is, if anything, less resistant than its tendon. On this account it is important to have 2 or 3 mm., or more, of tendon projecting beyond any sutures that are placed in it to bear traction; and not to excise the tendon all the way back to the muscle. It is to guard against the friability of the tendon that crossed sutures like those used by Swanzy, and the elaborate stitches of Worth, Suffa, and others, have been devised. But the stitch which best meets the requirements is one, which, running across the fibres holds the tissue of the tendon directly to that with which it is to be connected, as in the advancement operation preferred by the writer; or the stitching together of two layers of tendon in Savage's operation for folding, or Noyes' lapping of the tendon.

The difficulties of getting a firm hold for sutures at both ends make it important not to rely on such stitches to successfully resist any continuous pull. Advancement operations should in general accompany complete or almost complete tenotomy of the antagonist, which will for the time prevent any decided stress on the suture and the new formed attachments. If tenotomy be not done on the antagonist the keeping of both eyes closed for several days by bandages, and thus diminishing their active movements, is an inferior substitute. Advance-

[138]Noyes, H. D. *Text Book on Diseases of the Eye*, p. 172.

ment done alone is less efficient and less reliable. It is possible that, because of greater certainty of result, folding or tucking operations will supersede some other forms of advancement.

In all cases of advancement where the purpose is simply to increase the influence of the muscle operated on, it is important that the two edges of the muscle should be equally affected by the operation. The placing and tightening of stitches must be done with this in mind. Although the single stitch operations are often supposed superior on this account, the same care must be observed with them in the placing of the stitch. In the folding or lapping of tendons one should be shortened just as much as the other. Here there is at least a theoretical superiority for instruments like the triple hook of Clark, in which the three hooks are always strictly parallel, over the instruments like those of Todd and Levinson, in which the prongs or jaws have more or less of a scissors movement, and only with a certain amount of folding can the prongs or jaws be parallel. The anatomical changes actually produced by advancement operations are still uncertain, much less is known of them than about the clinical results of such operations, and it is probable that our judgment with regard to their clinical applications would be improved by a better understanding of the anatomical changes produced by operation.

It has been assumed that an advancement operation causes the tendon of insertion to form a new attachment to the eyeball at its anterior extremity; and to act upon this attachment as it did upon the original insertion. It is upon this assumption that the beautiful demonstration of the superiority of advancement over tenotomy of Landolt and his followers has been based. But the writer's experience in secondary operations agrees with that of others to indicate that the advanced tendon does not become attached to the eyeball simply by its anterior extremity, but rather that the attachment extends at least as far back as the original insertion of the muscle, and sometimes farther. This has been emphasized by Mueller.[139] Froelich[140] reports two cases in which this was proven to have occurred. Such reattachment of the tendons prevents any benefit from the attachment in the way of increasing the contact arc; although it does not necessarily cause such a diminution of the contact arc as tenotomy.

On the other hand instead of a too extensive insertion of the advanced tendon there is, after some forms of advancement, a risk that no firm attachment may be secured. The danger of this is slight if the antagonist has been rendered powerless by tenotomy. But where the antagonist retains its full power the danger is quite real, that after the

[139]Mueller. Beiträge zur operativen Augenheilkunde. *Klin. Monatsbl. f. Augenh., Vol.* XXXI, p. 118.

[140]Froelich, C. Tenotomy and Advancement. *Arch. of Ophth.*, 1905, p. 621.

removal of the mechanical support of the suture the new attachment will be so yielding or imperfect as to give way. This is the more apt to be the case in those forms of operation in which the advanced tendon is not stitched to the point at which a new attachment is to be formed; but is merely held in contact with that point by sutures which are anchored a considerable distance from the site for the new insertion.

C.—OPERATIONS TO ENABLE ONE MUSCLE TO TAKE UP THE FUNCTIONS OF ANOTHER.

Possibilities of Changing Actions of Muscles.

The recti muscles arise from practically a common origin. The peculiar action of each upon the eyeball depends on the relation of its insertion to the center of ocular rotation. If the insertion of the superior rectus muscle could be transferred to the normal position of the internus, and the muscle be at the same time freed from its intermediate attachments, it could perform the function commonly performed by the internus. If its insertion could be transferred to the normal seat of the insertion of the externus it would act like the externus. Any change in the insertion of one of the ocular muscles makes a corresponding change in its function. On this account a muscle wholly paralyzed can be partly replaced functionally by the transference of some other muscle. As each of the extrinsic ocular muscles takes part in different ocular movements, it is quite possible, by slight changes in the positions of their insertions, to so change the relations of their different actions as to readjust them to altered requirements caused by loss of function in one or more of the other extrinsic muscles. Some such effect is produced to a slight extent by partial tenotomy which divides one edge of a rectus tendon while leaving the other unaffected. This has been explained under partial tenotomy.

Ocular palsies commonly conform to nerve distributions. Thus paralysis of the fourth cranial nerve produces paralysis of the superior oblique muscle; paralysis of the sixth nerve paralyzes the external rectus muscle; and paralysis of the third or oculomotor nerve paralyzes the other four extrinsic muscles; the superior and inferior recti, the internus and the inferior oblique. Each of these conditions is to some extent amenable to operative treatment.

Use of the Superior Rectus to Correct Paresis of the Superior Oblique.

Contraction of the superior oblique causes intorsion, and helps to turn the eye out, or, when it is converged to turn it down. Paresis of this muscle causes extorsion, and weakness of movement outward and downward. Vertical diplopia, particularly with convergence and turning the eyes down as for reading, is one of the most striking symptoms. The

superior rectus opposes the superior oblique in regard to turning the eyes down; and tenotomy of the rectus has been done to remedy weakness of the oblique. The result has been unsatisfactory because, although the superior rectus opposes the oblique as to turning down, and to a less extent as to turning the eye out, it is the principal aid of the oblique in producing intorsion or opposing extorsion. Hence, although tenotomy of the superior rectus helps matters as to turning the eye down or out, it makes things worse as regards the tendency to extorsion which is left without efficient opposition. Moreover, the weakening of the superior rectus leaves the upward movements of the eye dependent on the inferior oblique. This latter muscle is exerted more strongly and tends to produce still greater extorsion. This is further discussed in the section on choice of operation for paralytic strabismus.

The change in the insertion of the superior rectus that is required to meet a failure on the part of the superior oblique must be one that, while diminishing its tendency to turn the eye up or in, will increase its power to produce intorsion, and give assistance in turning the eye far out. Such a change is produced by transplanting the insertion of the superior rectus backward and outward. The indication would be met, to a slight extent, by a partial tenotomy of the superior rectus which should divide all but the extreme temporal fibres of the tendon, leaving it to form a new attachment rather back and out from its original insertion. But in marked cases this is not sufficient, and a more radical transplantation must be performed, after careful calculation of the change of function desired.

Transplantation of the Superior Rectus.

The eye and instruments are prepared as for an advancement operation, the lids widely separated, and the eye turned strongly down. An incision is made in the conjunctiva, starting 8 mm. above the cornea, and 2 mm. to the nasal side of the vertical meridian of the eyeball; and extending 10 mm. outward and a little backward from that point. This is carried down to the superior rectus tendon, which is bared of subconjunctival tissue, raised on a strabismus hook, and "stripped" back for 8 or 10 mm. by passing the hook back on each side of the tendon. The sclera is laid bare to the outer side of the tendon as far back and to the temporal side as may be necessary, with rather free division of the capsule in this direction. A fine needle threaded with silk, is then passed about 3 mm. back from the insertion at the junction of the middle and temporal thirds of the tendon, from the conjunctival to the scleral surface, and brought out beneath the temporal edge of the tendon. The point of the needle is then entered in the sclera as many mms. outward and backward from the point of

introduction into the tendon as it is desired to displace the insertion, bearing in mind that each mm. represents about 5 degrees of change. The needle is carried in the sclera (deep enough to secure a firm hold, but not to perforate) for 3 or 4 mm., emerging that much nearer the nose than where it entered, and slightly nearer the cornea. The needle point is then introduced beneath the nasal edge of the tendon and made to emerge 3 mm. back from the insertion at the junction of the middle and nasal thirds of the tendon.

The suture thus placed is carefully drawn aside and guarded: and the tendon is divided at its insertion. Before the division the end of the tendon may be grasped (without excessive pressure) by advancement forceps. The tendon and eyeball are then to be brought into proper relative positions by forceps; and the suture drawn moderately tight, and tied so that the knot will lie in the conjunctival opening.

The after treatment includes closure with a light dressing for 2 or 3 days, and cleansing the eye once or twice daily. The suture can

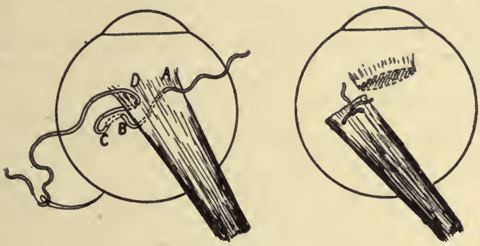

Fig. 345.

Transplantation of Superior Rectus for Paralysis of Superior Oblique. Introduction of suture before division of tendon; Suture tied, the original insertion of tendon shown by broken line.

be removed after 6 or 8 days; or sooner if there is evidence of a decided excess of intorsion. The effect to be aimed at is an exact correction, or slight over-correction, of the motor deficiency. It is presupposed that the case is of such long standing as to have become quite stationary. The effect in the three cases thus far done by the writer seems to be quite permanent, one of the cases now having been observed for 10 years.[141]

Change of Direction of the Line of Insertion of a Rectus Tendon.

For the correction of what he terms declinations of the eye, deviations of the meridians of the eye from their proper direction when the eye is in the primary position, Stevens[142] does an operation that he calls *extendo-contraction* of the muscle. It may be done on either

[141] Jackson, E. Operation on Superior Rectus for Paresis of Superior Oblique. *Ophth. Review*, 1903, p. 61.

[142] Stevens, G. T. *Motor Apparatus of the Eyes.* Philadelphia, 1906, p. 340.

rectus muscle, but Stevens' preference is in this order, internal, superior, external and inferior. A small opening is made just over the upper border of the insertion, through which, with the points of the scissors, a pocket is formed beneath the conjunctiva, extending almost to the cornea, and half the width of the tendon. The tendon is divided at its insertion for a few mms. only. A delicate sharp hook is carried beneath it as far back as necessary, and made to catch the tendon below its upper border and draw it forward out of the conjunctival opening. A fine, double-armed suture is passed twice through the exposed part of the tendon; after which the remainder of the insertion is divided. The needles are then carried forward beneath the conjunctiva, with the aid of a director, to emerge, one near the upper margin of the cornea, the other 4 or 5 mm. from the first. This advances the upper margin of the tendon, while permitting the lower margin to slip back, as shown in Fig. 346.

Transplantation of the Temporal Halves of the Superior and Inferior Recti Tendons for Paralysis of the External Rectus.

Two successful cases of this operation have been reported by Hum-

Fig. 346.

Change of Insertion of Tendon for the Operative Treatment of Declinations. (Stevens.) Broken lines show original position of tendon insertion. Dotted lines the new position.

melsheim.[143] His first patient, a girl of 12, with absolute congenital paralysis of the external rectus and inability to turn the eye beyond the median line, was given power to abduct the eye 30 degrees. The second, a woman of 47, with complete paralysis of the externus of 8 months' standing, and not benefited by other treatment, gained ability to turn the eye with monocular fixation outward 48 degrees, to preserve binocular distant vision to 16 degrees to the affected side and the binocular near vision to 30 degrees, and was relieved from very annoying diplopia.

The method of operation so far as described was a subconjunctival transplantation, using the technique of an advancement. An opening 12 mm. long was made over the tendon of the external rectus muscle. Through this the tendons of the superior and inferior recti were

[143]Hummelsheim, E. Ueber Sehnentransplantation am Auge. *Bericht der Ophthalmologischen Gesellschaft*, Heidelberg, 1907, p. 248. Weitere Erfahrungen mit partieller Sehnenueberpflanzung an den Augenmuskeln. *Archiv. für Augenheilkunde*, LXII, Bd. 1, 1908, p. 71.

reached, raised and split in the middle to about 12 mm. back from their insertions. The temporal half of each tendon was then separated from the eyeball at its insertion, and sutured to the insertion of the paralyzed muscle. The binocular bandage was used for 8 days, and the stitches removed on the eleventh day. No serious complications were encountered.

Transplantation of the nasal halves of the superior and inferior recti to replace the internus was tried by Hummelsheim upon a monkey, with success. The internal muscle was rendered powerless by excising a segment of its tendon and muscular structure; and the adjoining halves of the superior and inferior muscles were connected with the insertion of the internus. The animal regained good power of converging the eye and of turning it toward the opposite side.

Grafting of the Tendon of the Superior Oblique.

Transference of the tendon of the torn superior oblique to the external rectus has been reported by Dransart,[144] who also proposes the grafting of the tendon upon the upper edge of the externus or the nasal edge of the inferior rectus. He suggests an incision through the skin at the upper inner angle of the orbit to expose the oblique at the pulley, and tunneling from there to the new point of attachment and drawing the tendon into the new position by a suture.

Transplantations for Oculomotor Paralysis.

In paralysis of the oculo-motor nerve all the extrinsic muscles of the eyeball lose their power, except the external rectus and the superior oblique. These, being unopposed, turn the eye out, and the latter turns it somewhat down. Their action causes an unsightly deformity, although the extreme deviation, or the accompanying ptosis, usually prevents much annoyance from diplopia.

To prevent the extreme divergence the superior oblique can be taken up by the method described for tenotomy of that muscle, the tendon isolated, and divided far enough from the pulley toward the eyeball to furnish a sufficient length of tendon, the pulley then cut, the tendon drawn down and toward the eyeball, and the cut end of the tendon sutured to the tendon of the paralyzed internus near its insertion. This operation has been done by the writer upon the cadaver, but not on the living patient.

A still better position of the eye, and perhaps a little better movement, may be secured by subsequently splitting the external rectus for 15 mm. back from its insertion, and transplanting the upper portion to the temporal edge of the insertion of the superior rectus, and the

[144]Dransart. De la suppléance du muscle grand oblique par le muscle droit externe et par le muscle droit inferiour. *Révue Générale d'Ophtalmologie*, 1907, p. 229.

lower portion to a corresponding relation with the inferior rectus. It is possible that in a young person a limited field of binocular fixation and stereoscopic vision could thus be re-established.

D.—MISCELLANEOUS OPERATIONS TO INFLUENCE THE POSITION OF THE EYEBALL.

Passive Motion.

This was proposed by Michel[145] as a means of increasing the power of partially paralyzed ocular muscles. But Snell[146] has also used it to diminish the contraction of the internus in convergent strabismus. It is done under local anesthesia, but if done effectively is not without pain. The conjunctiva and tendon of the weakened muscle are firmly seized with strabismus forceps, close behind the insertion of the tendon; and the eyeball is forcibly rotated first in the direction of contraction of the muscle, then in the opposite direction, as far as possible with reasonable force. These movements are repeated rather slowly for about 2 minutes. This manipulation may be repeated daily if the irritation provoked does not demand a longer interval. Bull[147] reports eight cures in a series of twenty-one cases, while seven cases were partly relieved.

Stretching of Tendon and Connected Structures.

This was urged by Panas[148] as a remedy in ocular palsies and a valuable adjunct to tenotomy. After introduction of the strabismus hook beneath the tendon it is forcibly drawn upon until the cornea is partly buried at the opposite canthus. This dragging of the eye may be repeated several times, gradually increasing the effect. The tendon may be grasped with forceps and the eyeball alternately dragged back and forth. Or for very thorough stretching the hook may be passed under the opposing rectus. Thorough stretching is quite painful.

Division of the Check Ligaments.

This has been done as a means of increasing the excursion of the eye in the direction of the divided ligament; but the recorded experience is not sufficient to establish its effect. Parinaud[149] divided the conjunctiva and subconjunctival tissue parallel to the corneal margin

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[145]Michel. Ueber eine orthopaedische Behandlung von Augenmuskellähmungen. *Klinische Monatsblätter f. Augenh.*, Nov., 1877, p. 373.

[146]Snell, S. On the Etiology and Treatment of Convergent Squint. *Brit. Med. Jour.*, 1887, II, p. 661.

[147]Bull, C. S. Passive Motion in the Treatment of Paralysis of the Ocular Muscles. *Tr. Amer. Ophth. Soc.*, Vol IV, p. 450.

[148]Panas. De l'élongation des muscles oculaires dans le traitement du strabisme paralytique. *Arch. d'Ophtal.*, XVI, p. 1.

[149]Parinaud, H. *Bull. et Mémoires de la Société francaise d'Opht.*, 1893, p. 291.

half way to the canthus; and worked down by the sheath of the muscle until firm resisting tissue was encountered, which was divided.

Exsection of Tendons.

The older tenotomists divided the tendon or muscle far back when they wished to correct an extreme deviation, and sometimes excised the stump of tendon left by such a division. An operation of this kind may exceptionally be of service by eliminating the influence of a muscle left unopposed by the complete paralysis, or operation, or accidental functional destruction of its antagonist.

Prince,[150] who has reported the largest series of cases treated in this manner, recognizes four indications for this operation on the antagonist muscle: (1) Permanent atrophy or paralysis. (2) Irrecoverable loss of either rectus through accidental section of the muscle back of the capsular perforation. (3) Extreme over-correction of long standing following tenotomy. (4) Irrecoverable traumatic dislocation of the rectus. The muscle is to be taken up back of the point at which it pierces the capsule of Tenon. A sufficient portion of the length is isolated by use of the strabismus hook and scissors. This part of the muscle is then excised and the wound closed with a conjunctival stitch. At the same time such advancement as it is capable of should be done on the paralyzed or previously disabled muscle. Where this is still capable of contraction and of some influence on the position of the eyeball, care must be taken not to make the exsection so complete as to prevent any attachment reforming between the muscle stump and the eyeball. But where the paralysis is absolute the exsection of the opponent must be sufficient to remove its influence wholly and permanently. The range of usefulness of such operations will diminish with the more general adoption of lateral transplantation of the tendons of insertion.

Excision of Capsular Tissue.

The close connection of the muscle sheaths and tendons with the capsule of Tenon, check ligaments and other connective tissues of the orbit makes it possible to modify the position of the eye and the influence of a particular muscle upon the movements, without directly disturbing the muscle or its tendon of insertion. Dieffenbach[151] stated that he had cured a "great number" of persons who squinted slightly, by excision of a piece of conjunctiva over the insertion of the weakened muscle. This excision or cauterization of the tissue, either by the actual cautery or with silver nitrate, was done for paralytic squint, or the

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[150] Prince, A. E. Section and Exsection of the Rectus Muscles for Cosmetic Effect in Cases of Squint Inoperable by Tenotomy and Advancement. *Am. Jour. of Ophth.*, 1902, p. 259.

[151] Dieffenbach, J. F. *Die Operative Chirurgie*, Vol. II, p. 116.

lowest grades of "active squint." Cauterization could be repeated until marked thickening and contraction of the tissues was produced. This treatment was resorted to where it was feared that tenotomy would produce an excessive effect.

Excision of tissue is an important part of many advancement and shortening operations. In these, along with the tendon, parts of the capsule are usually removed. Sometimes, however, the tendon has not been included in this excision which, with the advancement, has been confined to the capsule and conjunctivà, as in the following operation suggested by Fox,[152] for divergent strabismus.

After tenotomy of the externus, the neighboring conjunctiva and capsule are thoroughly stretched by introducing a strabismus hook into the opening of the capsule, turning it first above and then below, and dragging the eyeball inward until the cornea is buried at the inner canthus. The tissues over the insertion of the internus are then

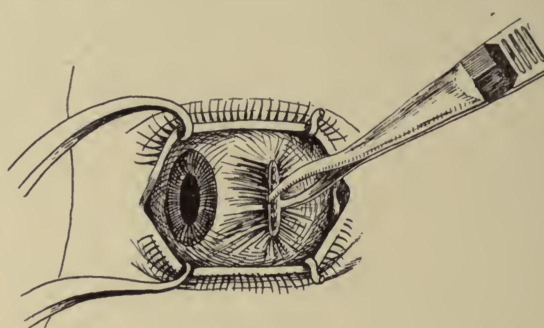

Fig. 347.

Method of Excision of Capsule and Conjunctiva for Divergent Strabismus. (Fox.) Tissues grasped in forceps ready for excision.

grasped with special forceps, as shown in Fig. 347, midway between the cornea and caruncle. The forceps are raised two or three times to take up redundant tissue. As much of Tenon's capsule as possible is included, but not the tendon of the rectus. The tissue grasped by the forceps is then cut off with one sweep of curved scissors. This leaves an elliptical opening which is closed by four sutures placed as shown in Fig. 348. The immediate effect aimed at is a convergence of 1 to 4 mm.

Advancement of the Capsule.

This was done by Parinaud[153] for convergent strabismus. It includes the excision of a vertical fold of the conjunctiva at the outer

[152]Fox, L. W. A Simple Operation for Strabismus. *Tr. Sec. on Ophth., A. M. A.*, 1900, p. 68.

[153]Parinaud, H. Operation du Strabisme sans Tenotomie. *Compte rendu des Séances de l'Académie des Sciences*, 1890, cx, p. 805.

side of the cornea. This is to be closed with sutures after opening the conjunctiva at the insertion of the internus, isolating the tendon by incision along its margin and completing the detachment of the capsule by cutting upward and downward from the insertion. In this way Parinaud claimed a change in the direction of the eye of about 15 or 20 degrees could be obtained, which might be increased to 25 or 30 by also dividing the insertion of the internus. The sutures were placed much as by de Wecker for advancement.

Partial Fixation of Globe.

This operation has been devised by Colburn[154] to secure the minimum of nystagmic movement in the most useful part of the field of fixation; and to improve the position of the eyeball in cases of complete paralysis. The eyeball is held in a central position, while a small incision is made in the temporal cul-de-sac of the conjunctiva.

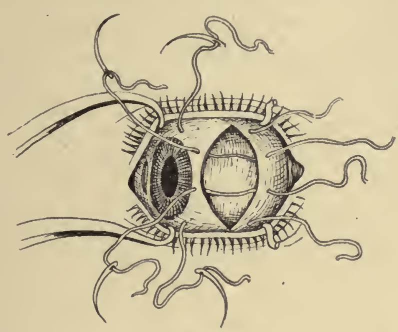

Fig. 348.
Advancement with Excision. (Fox.) After removal of tissue and introduction of sutures.

The eye is then rotated strongly inward, the cut just made is enlarged to expose the external rectus muscle. The tissue is then excised outward to the periosteum, a double-armed suture is passed through the external muscle, then deep into the periosteum and out through the skin, at the outer angle of the orbit; where it is tied over a button of plate tin, being sufficiently tightened to hold the eyeball in the desired position. The effect of the operation is to greatly limit the lateral movements of the eye, while leaving it fairly free to turn upward or downward.

GENERAL INDICATIONS FOR OPERATIONS ON THE EXTRINSIC MUSCLES OF THE EYEBALL.

These operations are done to rectify the position and improve the mobility of the eye. The muscles concerned are generally normal in

[154] Colburn, J. E. Fixation of the External Rectus Muscle in Nystagmus and Paralysis. *Am. Jour. Ophth.*, 1906, p. 85.

structure, and capable of the same physiologic contractions as the corresponding muscles of normally directed eyes. Concomitant strabismus, for which these operations are usually done, is not essentially a defect of muscular action, but a fault of co-ordination. To correct a co-ordination, a function of the brain centers, by alterations in the peripheral instruments through which brain impulses act, is an indirect and palliative sort of treatment. And considering the delicate accuracy of the ocular co-ordinations and movements, operative interference is only a clumsy means of approximate adjustment. Therefore operation is not to be thought of until more subtle measures, the modification of nerve impulses, by the wearing of lenses, regulation of eye work, use of mydriatics, or myotics, fusion training, etc., have been properly tried, and cannot be expected to bring about a better action on the part of the eye muscles. This demands that these operations shall not be decided on without rather prolonged study of the case and trial of other measures. The trial of correcting lenses requires months or years. We should even take into account the chance of gradual better development of the co-ordinating centers, and the slight tendency to divergence that comes with increasing age.

On the other hand the operative correction of the defect is at best only an approximate one. It brings about cure only in so far as it is followed by readjustment of nerve impulses. Such a readjustment of impulses, such an attempt to secure a more complete physiologic balance, is rendered possible by a wise disturbance of established relations; and occurs after every operative interference with the ocular movements. But such readjustments are more extensive, more complete, more permanent, more serviceable, and are accomplished with less annoyance, in proportion to the youth of the patient. In many cases we must confess inability to control the source of nerve impulses. All that we can do is to adjust the mechanical relations of the eyeball to its muscles in such a way that the nerve impulses and system of co-ordination that the individual has developed will give the best mechanical results; provided that under the use of glasses, and other means of treatment, these have probably reached a permanent state.

Any proper consideration of operation necessarily supposes a previous careful study of the kind and degree of motor anomaly present. The amount and direction of the deviation, its constancy or variations under conditions of general health or exhaustion, rest or use of the eyes, are to be previously known. For low degrees of deviation this demands considerable development and intelligence on the part of the patient, and operation should not be undertaken without the indications they furnish. But for gross anomalies of movement, careful repeated objective studies will furnish the data required, and operation may be

done without such minute exactness; but not without certainty as to the general character and permanence of the strabismus present.

Effect to be Aimed at in Operation.

The degree of deviation is commonly measured in:

Degrees, as on the arc of a perimeter or tangent scale.

Millimeters of displacement of the pupil or cornea, measured on the eyeball or edge of the lid.

Prism degrees, or centrads, or prism dioptres, as measured by prisms, the deviation being about one-half the degree of refracting angle, by which the prism is numbered.

One millimeter of displacement is about five degrees of deviation. Each degree of deviation is equal to 2 prism-degrees, or two centrads or two prism dioptres.

In planning an operation it is convenient to estimate the change to be produced in the direction of the eye in millimeters. This unit with its easily estimated fractions is as small as it is practical to consider, in estimating what is being done in a surgical operation. Attempts to be more exact, by resorting to subjective tests to estimate the result obtained, are more likely to introduce error than to increase exactness.

In estimating the probable effect of a given change in the position of the attachment of a certain ocular muscle, we must distinguish between two totally different conditions, A and B.

A. If we advance the tendon of the internal rectus muscle 3 mm. leaving the external rectus in normal condition, the increased tension will not be thrown wholly on the externus, so that the pupil will turn 3 mm. toward the nose. The increased tension will be divided between the two muscles. Each will be elongated one millimeter and a half. In the same way after simple tenotomy of the internus with the new insertion 4 mm. back of the old, the retraction has occurred half in the internus and half in the unopposed externus, and the eye will be turned only 2 mm. outward.

B. When, however, along with advancement of one muscle we do tenotomy of its opponent the effect produced on the direction of the eye is approximately equal to the distance of displacement of the muscle insertions. Thus, if the internus be advanced 4 mm. and the externus at the same time divided, the tendency of the latter to draw the eye out being removed, the turning of the eye in by operation will be the full 4 mm. of the displacement of the insertion. Indeed it may be more than this, because of contraction of the advanced muscle, which can act on the eyeball through the suture while the opponent is still unattached.

In attempting to correct upward and downward displacements the same differing conditions must be recognized. In dealing with tor-

sions we never divide the opponents and the case falls under class A. Indeed so many muscles are concerned in torsion that the displacement of insertion should even be rather more than double the change of angle desired.

Choice of Operation to Be Performed.

Theoretically, any case of strabismus might be treated by tenotomy of one muscle or advancement of another. For many years the only operation commonly practised, or written about, was tenotomy. Other operations, as advancements, were scarcely considered, except as correctives or adjuvants of tenotomy. Of late years the great bulk of the literature refers to advancement. One might judge from what is now written that tenotomy was quite superseded by it, and relegated to a subordinate position. But this is not the case in ophthalmic practice; although a few writers, led by Landolt, believe that tenotomy should be so relegated. Unquestionably, more harm has been done by tenotomy than by advancement. Tenotomy was the operation practised in the first operative furore, following the discovery that squint could be cured by operation. It was practised almost exclusively through the period of ignorance regarding the causation of squint by ametropia and the nature of binocular vision, and with the neglect of non-operative measures. It will still cause more bad results than advancement. For being more quickly and readily done, more immediately effective, and in all respects a less formidable operation, it will still be preferred by ignorant or reckless operators. But this does not prove that tenotomy in the hands of careful surgeons is not an extremely valuable operation; and the proper method of treatment for a large class of cases. The relative merits of tenotomy and advancement cannot be settled until the latter has had its day as a fad, and its failures and bad effects have been as unsparingly published and criticized as have been those of tenotomy. In the end the choice of operation will necessarily remain a matter for individual judgment. It is only possible here to review those facts and considerations that should be carefully weighed in coming to a conclusion.

After successful tenotomy the insertion of the tenotomized muscle is farther back on the eyeball; after advancement it is farther forward. The influence of this change on the ocular movements has already been adverted to in the account of the contact arcs and the check ligaments. Briefly tenotomy causes diminished, and advancement increased, power and range of ocular movement. This is graphically represented by Landolt.[154a] This reasoning, however, assumes that the advanced muscle actually acts upon the more anterior position at which

[154a]Landolt, E. Anomalies of the Motor Apparatus of the Eye. *System of Diseases of the Eye.* Edited by Norris and Oliver, Vol. IV, p. 111.

it has been attempted to attach it. But it has been claimed that after advancement the tendon becomes attached as far back as its former insertion. Velhagen[154b] found this the case. As pointed out in connection with the contact arcs such attachment does not give the advantages claimed. In a general way, other things being equal, greater power and range of movement are good things. But their importance can easily be over-rated. The periphery of the field of fixation is little used in practical affairs. Like the reserve capacity for breathing, or the limits of physical endurance which the ordinary demands of life never approach. The available field is much more diminished by the limits of an ordinary pair of glasses than by the effects of a carefully planned and executed tenotomy. As a practical result in high degrees of squint a good tenotomy will often actually increase the extent of the field of fixation, as well as make it more serviceable.

The *gradation of effect* is of greater practical importance in determining the choice of operation. Here, too, advancement has rather the advantage. In tenotomy the cut muscle is retracted to an extent largely independent of the technique of the operation. But an advancement can be exactly proportioned to the effect desired from the slightest to the greatest. Very slight effects may be produced, however, by partial tenotomy; and the effects of complete tenotomy of the internus may be increased by extending it to the adductor portions of the superior and inferior recti. This extension is also capable of fairly accurate gradation to meet the needs of the particular case, by variations in the extent to which the secondary adductors are divided.

Advancement is graded by the placing of the suture or sutures and the extent to which the tissues are drawn up by the traction of the sutures. It is customary to watch closely the effect produced during the operation and to modify the division of the tendon or the tension of the sutures to meet this immediate indication. But this ought not to be depended on to the neglect of careful calculation beforehand of the exact effect to be aimed at; and careful planning of the extent of the division of the tendon to be attempted, or the exact position in which a suture is to be placed. On the whole the results of careful plans based on fair experience will give better final results than attempts to obtain the correction desired by watching the immediate effect, and modifying the operation according to its indications. Only when some unforeseen factor intervenes and the effect produced proves quite different from that expected, is it wise to modify a carefully prepared plan of operation. Under the stress of operation with

[154b] Velhagen. Ueber die Narbenbildung nach der Tenotomie am menschlichen Augen. *Klinische Monatsbl. für Augenheilkunde*, 1909, Beilageheft, p. 19.

local anesthesia, the patient's answers as to the subjective tests become especially unreliable.

The operative *disturbance of tissue* is less with tenotomy than with advancement. Simple incision is always less of a disturbance than bending, twisting and traction of tissues, maintained for days by the introduction of a suture of foreign material. This advantage may not have attended some of the early tenotomies marked by very extensive mutilations of the connective tissue structures of the capsule of Tenon, and sometimes supplemented by thread fixation of the eyeball. But it does belong to the careful exact division of tendons without material damage to other structures, which constitutes modern tenotomy, confined to its proper sphere of usefulness, and not resorted to for conditions that demand its assistance by advancement or tendon tucking.

The *after treatment* of tenotomy is more brief, simple and safe, is less unpleasant and burdensome than that of advancement or of tendon tucking. After tenotomy, if a dressing is used, it is discontinued at the end of a day or two; and no sutures or clamps remain to keep up irritation and require removal subsequently. Even after extended tenotomy involving accessory tendons no soreness is felt after two or three days, and there remains only the ecchymosis and a hyperemia of the seat of operation. After other operations there is a greater soreness and swelling and conjunctival discharge increasing until the stitches are removed and dressings omitted.

In general it is better to do a *combined operation,* or to operate on more than one muscle, either at the same time or subsequently, than to attempt by increased disturbance of the parts to produce an effect greater than can be properly expected from the operation practised. When both eyes have equally good vision, and are about equally employed, it is best to *divide any marked operative alteration* between the muscles of the two eyes, as by doing tenotomy of both externi for extreme exophoria. But it is better to so choose and plan our operations as to secure the necessary alteration of ocular movements without having to operate twice on the same muscle. An exception to this may be noted with reference to tenotomy of the external rectus which may be repeated without harm, and sometimes with greater effect at the second operation.

Choice of Operation in Comitant Strabismus.

Here we have only to consider the amount of deviation and how it can be corrected with the least risk and discomfort to the patient, and the greatest freedom from disfigurement or limitation of movement.

There is general agreement that the slightest changes are to be effected by partial tenotomy, or by slight advancement or tucking with-

out division of the opponent. Greater effects are produced by complete tenotomy; still greater by decided advancements; and the greatest effects by advancement of one muscle with tenotomy of the opponent.

Very great effects secured by tenotomy of a lateral muscle alone are dangerous; because a condition of unstable equilibrium is established. The influences of both the primary adductor and abductor are diminished, and the lateral movements come to depend more on the secondary adductors and abductors. The primary adductor and abductor would bring the eye to a central position, the secondary adductors and abductors always carry it to extreme convergence or divergence. Hence when the influence of the latter preponderates, there is a strong tendency for the eye to again deviate as before, or in the opposite direction, from the influence of comparatively slight causes. Relapses, or eyes turned the other way, are among the effects of attempting to correct by tenotomy strabismus of too high degree to be properly amenable to that operation. After the above general review of the subject a specific recommendation of operations is permissible. The author prefers:

For Excess of Convergence, Esophoria or Esotropia.

Less than 5 degrees (ten centrads of ten-degree prisms) partial tenotomy, central. (Stevens' method.)

Five to twelve degrees (10 to 24 centrads), advancement or tendon-tucking, without division of externus.

Twelve to fifteen degrees (2.5 to 3 mm.), complete tenotomy.

Fifteen to thirty degrees (3 to 6 mm.), extended tenotomy.

Above thirty degrees (6 mm.), advancement of the externus, with tenotomy of the internus, extended if necessary.

In squint of high degree over 20 degrees (4 mm.), operate on the deviating eye, attempting to correct two-thirds or three-fourths the total squint, and expecting to complete the adjustment by subsequent operation on the fixing eye.

For Divergence or Deficient Convergence, Exophoria or Exotropia.

Three to five degrees (6 to 10 centrads), complete tenotomy.

Five to ten degrees (1 to 2 mm.), advancement of the internus or free tendon tucking without division of the externus.

Ten to twenty degrees (2 to 4 mm.), advancement of the internus with complete tenotomy of the externus.

Twenty degrees and upward, advancement of internus with tenotomy of externus, and anchorage of eye to nose with threads. For higher degrees of divergence such an operation may be done on both eyes simultaneously. The threads may be cut if there seems to be danger of too great an effect. Or for a later adjustment increasing the

effect tenotomy of the externus may be repeated with or without the use of a thread anchorage to the nose.

Choice of Operation for Paralytic Strabismus.

Here other factors besides the degree of deviation have to be equally considered. In so far as the paralysis is absolute the ordinary operations of tenotomy and advancement are of little value. But in the great majority of cases some power is retained or recovered by the affected muscle or muscles.

There occurs, too, a gradual readjustment of muscular actions, so that the function lost becomes largely replaced, and the movements at first impossible can be executed by the subsequent contractions of muscles on which they do not normally depend. It might be supposed that a deviation caused by loss of power in a particular muscle should always be met by advancement of that muscle to increase its influence. But advancement fails to produce this effect if the power of muscle contraction has been lost; and loses its influence in proportion as this power is weakened. It is pre-eminently true of paralytic strabismus, that every case must be the subject of special study, if the operation best suited for its correction is to be chosen.

For illustration suppose a case of paresis of the right superior oblique. The most marked symptom is failure of the eye to turn down, but with some weakness of outward movement and some extorsion. Even with an advancement of the affected muscle out of the question, the operative possibilities to be considered are quite complex. We might advance the right inferior rectus which normally assists the affected muscle in turning the eye down. Or we might do tenotomy on the right superior rectus, an antagonist of the superior oblique in vertical movements. Again we might do tenotomy on the left inferior rectus, or advancement of the left superior rectus in the hope of making downward movement as difficult for the left eye as disease has made it for the right. But advancement of the right inferior rectus, or the left superior rectus would rather increase the tendency to convergence. Again, tenotomy of either superior rectus, or advancement of either inferior rectus will tend to increase the extorsion, while advancement of a superior rectus, or tenotomy of an inferior will correct the extorsion. Taking all these things into account Alfred Graefe[155] concluded that the indications were best met when paralysis of the right superior oblique was treated by tenotomy of the left inferior rectus. This would diminish the power of the left eye to turn down as the power of the right had already been diminished by disease. It would also diminish

[155]Graefe, Alfred. Die Indicationsstellung bei operativer Behandlung der paralytisch bedingten Deviationen eines Auges. *Graefe's Archiv. f. Ophth.*, XXXIII, pt. 3, p. 179.

the tendency to convergence and would tend to produce an intorsion of the left eye that would balance the extorsion of the right.

But there are yet other factors that have to be taken into account. If the patient were compelled to use the eyes turned down, as in reading and in most kinds of close work, the diminution in the power to turn them down might be a serious drawback. If the eyes were habitually used turned down and to the right the disturbance of the turning down might be very much more important than the disturbance of torsion. In one case the inability to turn the eye down might be the only serious impairment of the patient's power. In another case the disturbance of torsion might far over-balance everything else.

Operations to affect the vertical movements are almost always called for on account of some paretic condition, and the absence of details in reported cases leaves it impossible to estimate the effects to be expected from either tenotomy or advancement in a case of paralytic squint. Such lack of detail also renders worthless such statements as, more effect is produced by operation on the superior than the inferior muscle. Or that it is always better to do an advancement than a tenotomy for paralytic squint. In view of these facts any general statement as to the choice of operation would be worthless. Success is to be obtained by thorough repeated study of the deviations and limitations of movement present in the particular case; after the period of readjustment, always many months and better one or more years, from the occurrence of the paralysis. The amount of effect we can expect from a given operation in comitant squint is roughly known; and in so far as operation is indicated in paralytic squint it may be expected to have a similar effect. But mostly there is in the latter class of cases less danger of an over-effect.

Returning to our illustration of operative possibilities in a case of paresis of the right superior oblique. If the limitation of movement were very slight one might do partial tenotomy of the right superior rectus; leaving the temporal fibres of the muscle undivided so as to increase its tendency to oppose extorsion, while diminishing its power of preventing the eye from turning down. If the disturbance of torsion were very slight and the vertical deviation great, the tenotomy of the right superior rectus might be made complete. If the patient were not required to do any accurate seeing with the eyes turned down, tenotomy of the left inferior rectus could be done. But if the effects of the paresis are more serious the lateral displacement of the right superior rectus, as devised by the writer, carefully adjusted to the conditions present is indicated. Only after some such review of therapeutic possibilities should one plan an operation for paralytic squint.

Caution.

In regard to all operations on the extrinsic ocular muscles: Operate only after thorough study of the case, including trial of appropriate non-operative treatment; and bear in mind that the final result of operation may only be reached after many weeks or months, but that any failure to correct the defect may be evident to all who know the patient so long as he may live.

CHAPTER IV.

SURGICAL TREATMENT OF INJURIES TO THE VISUAL APPARATUS.

By HARRY VANDERBILT WÜRDEMANN, M. D., Seattle, Wash.

The Conservation of the Wounded Eye—Emergency Cases—General Therapy—Preparation for Operation—Sepsis—Surgical Technique of the Wound—The Conjunctival Cul-de-sac—Lids and Surroundings—Lachrymal Passages and Nose—Infected Wounds—Anesthesia—Analgesia—Conjunctiva—Wounds—Foreign Bodies—Fire Arms—Operations with the Conjunctiva—Kuhnt Conjunctival Flap—Keratoplasty—Conjunctival Implantation without Flaps—DeWecker Temporary Covering of Conjunctiva—Author's Pouch Suture—Maddox's Lattice Suture—Koyles' Operation—Deane's Double Suture—Cornea—Wounds—Corneal Suture Cauterization of Ulcers—Keratomy or Saemisch Section—Flushing of Anterior Chamber—Injection of Antiseptics and Introduction of Iodoform—Subconjunctival Injections—Foreign Bodies—Sclera and Corneo-Scleral Margin—Wounds—Scleral Suture—Injuries at Ciliary Region—Cystoid Cicatrices—Foreign Bodies—Ruptures—Nuel's Suture—Author's Matress Suture—Uveal Tract—Wounds and Prolapse of Iris—Zehender's Operation—Heckel's Procedure—Nicati's Operation—P. Chalmers Jameson's Operation—Prolapse of Choroid and Ciliary Body—Foreign Bodies—Iridodialysis—Lens—Traumatic Cataract—Medicinal Treatment —Bandaging—Paracentesis—Discission—Linear Extraction—Irrigation—Operation in Sympathetic Cataract—Foreign Bodies—Dislocation—Vitreous and Foreign Bodies in Interior of Eye—Cornea—Anterior Chamber—Iris—Lens—Posterior Segment—Paralental Route to Vitreous—Removal of Magnetizable Bodies—Removal of Non-magnetizable Bodies—Retina—Wounds—Foreign Bodies and Detachment—Optic Nerve—Lids —Wounds—Plastic and Other Operations—Foreign Bodies and Combustions—Burns from Acids and Alkalies—The Lachrymal Apparatus—Wounds—Dislocation of Gland—Foreign Bodies—Muscles—Orbit—Wounds—Foreign Bodies—Supraorbital Neuralgia—Fractures of the Walls of the Orbit.

THE CONSERVATION OF THE WOUNDED EYE.

The treatment of a wounded eye should be conservative from the first, to retain as much vision as possible, to preserve the cosmetics of the organ, and in some cases even to save life, as well as to relieve the agony of the injury.

With this maxim in view we must consider first those methods

which will give the best results as regards vision, and secondly, as regards the appearance of the globe and its surroundings, bearing in mind always the dread possibilities of sympathetic disease in the other eye, and remembering the operation of enucleation or its substitutes with which to combat this possibility. A most trivial injury, may, through neglect, ignorance, or mismanagement, result in total loss of vision in one or both eyes, disfigurement or even death; in all cases there will be damage to the earning ability, pain and suffering all out of proportion to the same character of injury inflicted upon other structures of the body.

General Therapy.

As a rule an injury to the eye immediately incapacitates a person from pursuing the employment of the moment, be it business or pleasure, and he may be so blinded as to, in dangerous surroundings, fall into imminent danger of life and limb and so must seek or be led to a place of safety. But few ocular accidents are attended by severe nerve shock as evinced by loss of consciousness, but such as occur are to be treated by fresh air, the dashing of water in the face, chafing the hands and stimulants. Immediate, severe pain may be met by narcotics, especially by hypodermics of morphine; but, as a rule, cases of ocular injury are ambulatory and seek the physician in his office or at the hospital clinic.

The public should be taught that the *first aid* to injured eyes is as a rule to let them alone, except to apply a clean cloth bandage and to immediately seek a physician, more especially an oculist; except where large quantities of foreign materials, such as sand, dirt or corrosive substances (lime or chemicals) enter the eye, when the first application is free douching with clear, clean water. The use of such house remedies as tea, milk, honey, urine, beefsteak, poultices of bread and milk, antiphlogistine, chamomile, sage-tea, or other applications is to be deprecated, for all of these only assist the growth of germs and act as a poultice. The eye is in no wise a "boil to be drawn out!"

Asepsis.

The therapy of the wounded eye is based upon general surgical principles and from beginning to end the watchword is *asepsis*. The surgeon's hands should be clean, his dress neat, and while surgical millinery is superfluous in ophthalmic practice for the most of our work, yet the clean shirt, the changing of the street coat for the white dressing coat when handling cases, and the absence of a beard are details of his personality that prevent in some measure infecting his own patients.

When a patient with an injured eye enters a hospital, as a rule,

unless contra-indicated by his class and appearance, or the necessity of preventing jarring of the eye, a full bath is indicated, and, perhaps, a special preparation of the ocular surroundings by soap and water, 1:5,000 sublimate compress and light bandage, unloading of the lower bowel by a saline (a rectal injection if necessary) for general anesthesia and, if the time warrants, such general care as for other surgical cases.

My rules[1] in cases of injury to the ocular apparatus requiring operation, are the following:

Head. Shampoo with green soap the night before the operation.

Face. Wash thoroughly with green soap, and after further cleansing with plain water, use a solution of 1:10,000 bichloride the night before the operation.

Nose. Irrigate with warm Seiler's solution the night before the operation and again on the morning of the operation.

Eye. Wash the eyelids and eyebrow carefully with green soap, and after rinsing with hot water use a solution of 1:10,000 bichloride. Wash the eye thoroughly with warm boric acid solution and instill argyrol 50 per cent; a bichloride pad 1:10,000 to be placed over the eye and bandaged all night. Repeat this on the morning of the operation.

General. Give the patient divided doses of calomel, one-fourth grain at a dose every half-hour for four hours the night before the operation, and follow with one-half ounce of magnesium sulphate in the morning. Do not allow the patient who is to have a general anesthetic any food the morning of the operation.

It must be remembered that, as Praun[2] says, "*Halbe Aseptik ist schlechter als gar keine,*" for it gives a false security.

But, as a rule, injured eyes in ambulatory patients are first seen by the physician at his office. They generally come with a more or less clean bandage applied by themselves, by friends or some other physician, and the after-treatment in most cases is carried out by the physician at his office.

A general rule in this class of cases is not to allow the injured one or anybody else to touch the eye or make any applications until the external wound has healed and there is no longer danger of infection.

C. S. Bull[3] discusses the various sources of infection following operations on the eye, the most frequent being the edges of the eyelids, the conjunctival sac, and the lachrymal canaliculi and sac. He points out the well-known fact that a normal conjunctival sac, free from noxious bacteria of all

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[1]Würdemann. *Injuries to the Eye and Adnexa;* a Practical Handbook for the Physician and Ophthalmic Surgeon, with References to Forensic Procedures and Visual Economics. Phila., 1911.

[2]Praun. *Die Verletzungen des Auges*, Weisbaden, 1899.

[3]Bull. Operations upon the Eyeball in the Presence of an Infected Conjunctival Sac. *Medical Record*, Sept. 24, 1910.

kinds, does not exist, citing Gayet's, Rymowicz's, and Fick's experiments in proof of this.

Surgical Technique of the Wound.

In general we do five things. (1) Render the conjunctival cul-de-sac, the lachrymal passages and the nose, as well as the lids and skin surrounding the eye, as free from germs as possible. (2) Replace or cut away prolapsed structures. (3) Sew up the wound or coapt its edges in other ways. (4) Use after-treatment by some antiseptic that will prevent the entrance and development of microörganisms. (5) Keep the wound quiet and occluded by bandaging, the ciliary body at rest, and the pupil opened by cycloplegics.

The *cleansing of the cul-de-sac* is, of course, more difficult and has to be accomplished as an emergency procedure more generally *in ocular injuries* than in cases that are to be prepared for an operation.

Fig. 349.
Elwood Wash Bottle.

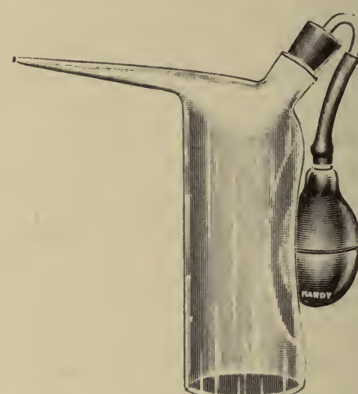

Fig. 350.
Todd Wash Bottle.

This should be done with chemically indifferent solutions, as douching with normal salt solution or 3 per cent boric acid. These are best injected into the eye by the syphon bottle of Elwood[4] or Todd[5] or the undine which keep the solution from contact with the air and prevents its contamination. The rubber bulb, glass-ended syringe, or other forms of the eye douche, or even a sterile medicine dropper (in emergencies) are also quite useful irrigators.

Bach[6] and Franke[7] in several articles and other writers as well, have claimed from bacterial examinations that "the best method for sterilization of the conjunctival cul-de-sac consists in mechanical

[4]Elwood. Wood and Woodruff. *Commoner Diseases of the Eye*, 1904.
[5]Todd. An Improved Eye Irrigator. *Ophth. Record*, Feb., 1904, p. 60.
[6]Bach. *Arch. f. Ophth.* XL, 3; and *Arch. f. Aug.* XXX, 2-3.
[7]Franke. *Arch. f. Ophth.* XLIII, 1.

cleansing, followed by syringing with an antiseptic solution, especially sublimate 1:5,000." But the irritation caused by such an application results in the exudation of mucus, which is a fertile medium for germs, and hence the chemically indifferent solutions are generally preferable.

In America the advocacy of a specially prepared 1:3,000 sublimate in petrolatum has been made by White[8] and reported upon favorably by others. I like this, too, but only as an application to the eyelashes or for after-treatment. Other solutions of value for this purpose are mercury oxycyanide, 1:3,000; chinosol, 1:1,000; hydrogen peroxide, 1:15.

It has been shown that it is impossible to entirely free the conjunctival sac from germs, yet by such means their number is so reduced and their possibilities of reproduction so hindered that the eye may be made practically free from danger of infection.

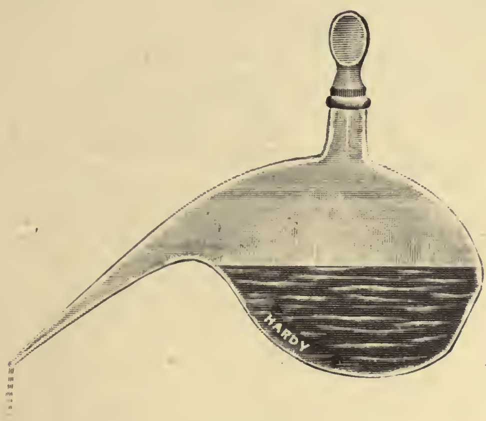

Fig. 351.
Undine.

The removal of catarrhal nasal secretion by douching before an operation or surgical treatment of ocular wounds of any gravity with mild saline, antiseptic solutions as Seiler's, Dobell's or other formulæ is indicated. For this the rubber bulb syringe or glass nasal douche is used, the solution being injected without force and the nose gently blown clear of secretion by the patient.

The formula is as follows:

℞

Hydrarg. Bichlor.	.06	gr. i
Sod. Chlorid.	.30	gr. v
Aquæ	.50	gtt. viii
Tritura et adde		
Petrolatum	200.00	℥ vi

For definite directions in preparing this valuable mixture see Wood's *System of Ophthalmic Therapeutics.*

[8]White. *Trans. Sec. Ophth. A. M. A.*, 1898.

Cleansing the Lids and their Surroundings.

After ocular injuries requiring operation, the skin of the lids and face is cleansed with green soap and water, then with alcohol, and afterwards with 1:5,000 sublimate solution. Gauze wet with the latter may be laid upon the eye during a half-hour preceding the surgical work, or if time be given the full preparation as for an operation, previously described. It is seldom necessary to cut the lashes, but often to shave the eyebrows.

F. G. Murphy[9] maintains that "as the mucous membrane covering the eye is continuous with that lining the nose, the one may be readily infected from the other. Ulcers and injuries to the eye often do not do well because this source of infection is not generally recognized."

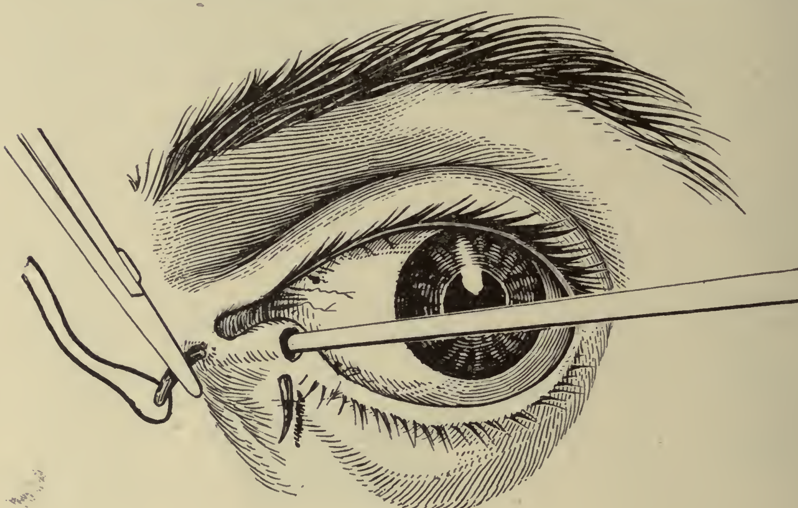

Fig. 352.
Taylor's Method of Tying the Canaliculus in Dacryocystitis before Operation Involving the Opening of the Eyeball, as Adopted by the Author.

Cleansing the Lachrymal Passages.

If upon inspection and manipulation the tear sac is found free from pus, evinced by pressure inwards and downwards with the finger tip, it may be left alone. If suspicious, a weak argyrol or fluorescin solution may be injected by way of the canaliculus to the nose, when upon gentle use of a handkerchief the stain will be found if the passages are patent.

If the *tear sac be infected* our troubles begin, for here we have the nidus of the pneumococcus, the staphylococcus and the streptococ-

[9]Murphy. Nose Treatment and Injuries to the Eye, *Iowa Medical Journal*, Nov. 15, 1904.

cus. Long previous treatment, advised in similar complications of cataract extraction is not possible in ocular injuries. Casey Wood[10] shuts off the canaliculi temporarily by passing a needle under the lower tube, coming out above the upper and tying the same.

S. J. Taylor[11] also points out that the modern plan of thoroughly dissecting out a diseased lachrymal sac before performing any operation upon the eye in which the globe is opened is the one to be adopted in the vast majority of cases. But this procedure may, at times, be undesirable, especially in old, decrepit patients. In such examples the writer has successfully adopted the plan of ligating the upper and lower canaliculi.

The parts are well cocainized, some powdered cocaine being applied, a fine probe is passed into the canaliculus and held by an assistant or nurse against the wall of the nose; then a small, well-curved needle, armed with a double silk ligature is passed under and around the probe, taking up a little more tissue than the canaliculus only; whereupon the probe is withdrawn and the double ligature firmly tied. The same is done to the other canaliculus and communication with the sac is thus entirely shut off, as can be proved by there being no more regurgitation of pus when pressure is made over the sac.

Immediately after the ligatures have been applied, the conjunctival sac is well washed out with sublimate solution and the operation proceeded with. Very little reaction follows the application of the ligatures, the dressings and after-treatment are not in any way modified; the ligatures often cut out or can be removed a few days after insertion, long before which—especially if a conjunctival flap is secured—the wound in the globe is healed and free from risk of infection.

The puncta may be temporarily obliterated by the galvano-cautery, or a radical extirpation of the lachrymal sac may be done in infected lachrymal passages prior to operations for injury to the eye. At any rate the puncta should be slit, the lachrymal sac thoroughly syringed with antiseptic solution, and the inner canthus strewed with powdered iodoform, leaving the radical operation to be done later. In passing it is well to refer to the efficacy of the Kuhnt conjunctival flaps (q. v.) in preventing infection of corneal wounds.

Surgical Treatment of Ocular Wounds.

This should be carefully done by mopping the parts with cotton, wet with a mild antiseptic solution. All foreign bodies should be removed, a prolapsed iris or portions of the ciliary body cut off, the wound edges coapted—if small, without sutures. Scleral wounds may be

[10]Casey A. Wood. Personal Communication, 1900.

[11]Taylor. Operations on the Globe in Presence of Chronic Dacryocystitis. *Ophth. Review*, Oct., 1909, p. 279.

covered by sliding conjunctival flaps, if large, additional sutures are taken in the sclera itself. Perforating corneal wounds are best covered at once by the Kuhnt method (q. v.) by which I have saved many eyes. It is not only difficult but often impossible to suture corneal wounds on account of the necessary handling causing prolapse and loss of the ocular contents.

Antisepsis of the wound has been best achieved by me with 50 per cent freshly prepared argyrol solution, with which the eye is flooded upon completion of its toilet. In suspected infection I commonly inject a few drops of this solution into the anterior chamber. This causes no irritation and saves infection. The Haab method of inserting an iodoform rod into the anterior chamber has not been generally adopted. In former years and now in Europe powdered iodoform is liberally strewn on wounds of the eye, but in recent years it has been shown that the antiseptic qualities of the chemical are poor and its disagreeable odor and irritative action have caused it to pass into disuse.

Infected Wounds.

Should the wound be infected, after due cleaning a solution of argyrol (50 per cent.) should be freely instilled. If hypopyon ulcer has formed, a free cauterization should be made and the eye filled with argyrol solution, or 1:3,000 sublimate ointment, and bandaged; or the open treatment by hot applications one-half hour every three hours, with frequent instillations of argyrol and sublimate 1:10,000 douching may be substituted.

Subconjunctival injections (q. v.) of 1:5,000 mercuric chloride or cyanide are advocated by Darier[12] and others for intra-ocular suppuration, and even normal salt solution has in my hands been efficacious in saving many eyes.

After cocainization the lids are held apart by an assistant, the conjunctiva near the limbus seized by a catch forceps, and a half to full hypodermic (preferably a glass Luer model) syringeful injected under the conjunctiva. This is immediately raised into a bleb which passes away in about a half-hour, leaving a slight redness and but little irritation. Several such injections may be repeated after 24 hours' interval.

After-treatment. The after-treatment consists in: 1. An occlusive but *not* a pressure bandage. We know from the work of Bach[13] that the secretions of the eye which may contain microörganisms are carried by the lid movements through the tear passages to the nose, and that the ocular secretions are feebly antiseptic. We should not impede these natural safeguards by a pressure bandage; it is sufficient to pro-

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[12]Darier. *Thérapeutique Oculaire*, p. 32.
[13]Bach. l. c.

tect the wound from actual contact with the fingers of the patient and the outer air.

Bandaging in Ocular Injuries.

There are all styles, shapes and kinds of occlusive bandages. For trivial injuries, as simple, recently impacted foreign bodies in the conjunctival cul-de-sac or cornea it is my custom, after removal, to secure partial closure of the lids and immovability of the upper lid by applying semilunar piece of adhesive plaster shaped to the cartilage of the upper lid. This is removed by the patient the next day. Court plaster slips may also be applied over the closed lids. Absorbent cotton behind a pair of smoked or amber glasses makes a light bandage for the day. The use of absorbent cotton held in place by two strips of adhesive plaster to the forehead and cheek makes an occlusive dressing that may be replaced night and day.

More permanent protection is afforded by the roller bandage, the two-or three-tailed bandage, and that for both eyes by the Moorfields four-tailed bandage. Where protection from the fingers or hands of

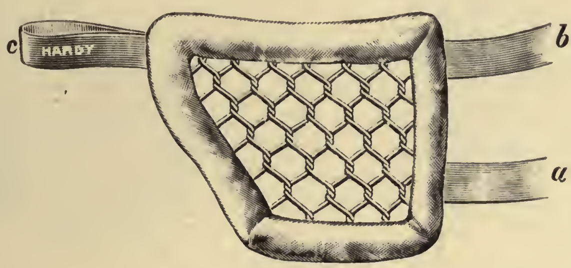

Fig. 353.
Fuchs's Wire Mask.

the patient is needed the single or double wire mask of Fuchs, Frothingham[14], Emerson, the author's model, the papier maché mask of Ring, or such protectors as the cocoanut shield of Westhoff[15], may be used. Necessity has led Westhoff to the employment of the cocoanut shell as a protector to the eye after operations. He employs various sizes, perforated for ventilation and attached to the forehead and cheeks by strips of adhesive plaster. They are light, can be boiled and used with any antiseptic fluid. Wolffberg commends them and believes they may serve other useful purposes.

In all cases where a roller bandage is to be occlusive and not intended to slip or press upon the eye it should be held firmly in place by

[14]Frothingham. Personal Observation, 1900.
[15]Westhoff. The Use of the Cocoanut Shell as an Eye Shield, *Wochenschr. f. Ther. u. Hyg. d. Aug.*, June 14, 1906.

long strips of adhesive plaster wound around the head rather than trusting to pins.

Compressed cotton, lintine, or a single layer of gauze prevents the cotton from getting into the lid aperture. Where lintine is used it is my custom to apply it moistened with antiseptic solution. Drying in a few hours it conforms to the lids and makes a serviceable splint.

In all cases it is my custom to instill 25 per cent or 50 per cent argyrol solution and to apply aseptic petrolatum or White's sublimate ointment to the lids before applying the bandage. As a rule bandages are removed in 24 hours and the eye dressed again.

Leeching[16], always in these enlightened aseptic days by the artificial leech applied at the temple near the outer canthus, is used when there is great pain and chemosis. It gives relief by depleting the local circulation and perhaps, also, by counter-irritation.

Atropine is nearly always indicated, as it puts the pupil in a position where iritis may occur without resultant adhesion of the pupil or formation of synechiæ; and likewise quiets the ciliary muscle.

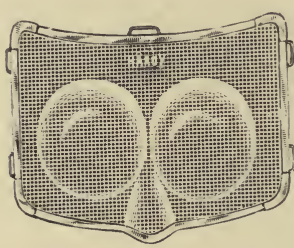

Fig. 354.
Emerson's Double Wire Mask.

Fig. 355.
Ring's Papier-Maché Mask.

Exception is to be made in non-penetrating wounds where the *intraocular tension* may be raised, when *eserin or iridectomy* is indicated. Eserin has been disappointing in wounds at the border of the iris, and has only been useful in radial tears.

Argyrol, White's ointment, antiseptic washes of boric acid, sublimate, oxycyanide and chinosol have been useful in the after-treatment.

Anesthesia.

On account of the local pain, photophobia, and lachrymation, it is generally necessary to apply a local anesthetic to the injured eye before the examination can be proceeded with. Of these, solutions of cocain 5 per cent, holocain 1 per cent, eucain 2 per cent, stovain 1 per cent, or alypin 2 per cent are in most common use. In grave injuries to the

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[16]MacWhinnie. A New Artificial Leech. *New York Medical Journal*, Dec. 3, 1909.

orbital tissues and lids, where enucleation is immediately necessary, or in exceptionally hysteric or nervous individuals only will a general anesthetic be necessary.

In no case should a local anesthetic, as cocain, be entrusted to the patient's hands for the relief of pain, for such a remedy breeds a false security, pain being Nature's warning of danger and call for relief. All of these anesthetics frequently repeated, especially in the case of cocain, cause damage to the tissues.

Vossius[17] gives preference to cocain over stovain, alypin and novocain. He performs extirpation of the lachrymal sac almost always under local anesthesia with cocain and adrenalin, a mixture which appears in the market, sterilized, under the name of eusemin.

Analgesia.

Dionin is a true analgesic and may be freely used in 5 per cent. and 10 per cent. solutions. After the first few applications the edema of the conjunctiva caused by it does not recur, but the analgesic effect

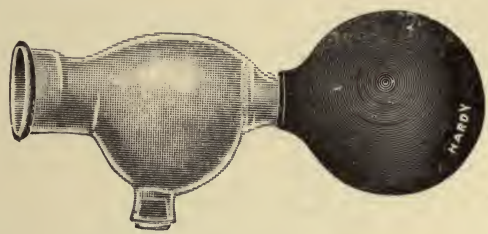

Fig. 356.
MacWhinnie's Artificial Leech.

remains unimpaired, giving more or less relief from acute pain for from three to twelve hours after each instillation.

Rest of the ciliary muscle and iris by cycloplegics and mydriatics is helpful in preventing pain, as well as in other ways. Atropin in 1 per cent. solution is efficacious.

In exceptional instances morphine may be administered by hypodermic injection in .01 to .02 doses.

INJURIES TO THE CONJUNCTIVA.

Wounds, cuts, stabs and other mechanical injuries of the conjunctiva are frequently met with and may be associated with wounds of the same character in the lids or cornea. The conjunctiva may be incised, transplanted, stretched and maltreated in many other ways without permanent injury to it or to the function of the eyeball. Small

[17]Vossius. Local Anesthesia in Eye Operations. *Deut. Med. Woch.*, No. 49, 1906.

wounds need little treatment except asepsis or antisepsis. If the solution of continuity be sufficiently great one or two interrupted stitches may be taken to be removed on the fourth or fifth day after operation, when healing is usually to be expected. However, a crack in its armor allows of the entrance of pathogenic germs to the ocular tunics, and infection (especially by the streptococcus or staphylococcus) may follow, although it rarely does. Destruction of large portions of the conjunctiva, especially when both the ocular and palpebral parts are involved, leads to adhesion of the lids to the eyeball, which in some cases is extensive, as in burns from acids or alkalies, when a symblepharon may form. Operations for this condition have been in vogue since time immemorial, and are discussed in Beard's chapter.

If the destruction of conjunctiva involves the inner canthus the lids, as well as the lachrymal puncta may grow together, and the condition known as anklyloblepharon is the result.

If an erosion occur at the edges of the corneal limbus the conjunctiva may encroach upon the cornea, become hypertrophied and form a pseudo-tumor mass, which is given the name of pterygium, operations or which are described elsewhere in this *System*.

Conjunctival Foreign Bodies.

Foreign bodies on or in the conjunctiva are of less moment than those in the cornea as they are usually removed by the tears, or by the patient himself. Foreign bodies getting into the eyes, passing under the upper lids and becoming impacted between the lid and the cornea, give rise to grave irritation and temporary blindness, such patients being unable to resume their vocation until the offenders are removed. Other foreign bodies may pass into the folds of transmission in the upper conjunctival cul-de-sac, where even large objects may remain for a long time without causing much discomfort. This condition is often seen by ophthalmic surgeons, especially in the case of flax seeds, the so-called "eye-stones," particles of wheat husks, corn, beads, etc., which may remain in this locality for a long time without causing much discomfort compared to the excessive irritation set up by gritty substances on the cornea or surface of the upper lid. The gush of tears in most cases washes away the intruders. In persons who are acquainted with the procedure, it is easy to seize the upper lid by its lashes and pull it down over the lower lid, the lashes of which may brush the foreign body away. In other cases the end of a handkerchief may be rolled into a cone and passed between the lids; in still others the patient will find it necessary to consult a surgeon for removal of the foreign body.

Method of Removing a Foreign Body from the Conjunctiva.

The patient should sit in a chair with his face towards a window so

that the eye may be well lighted, or with his back to a window or a light, the physician using the light from his head mirror. The lower lid should be turned down, the lachrymal puncta carefully examined, the cornea thoroughly scanned and then the upper lid everted. The physician now stands behind his patient, grasps the lashes of the upper lid with his left forefinger and thumb, pulls it slightly away from the globe at the same time passing a probe or small object along the skin of the upper lid, pressing downwards and forwards so as to turn the edge of

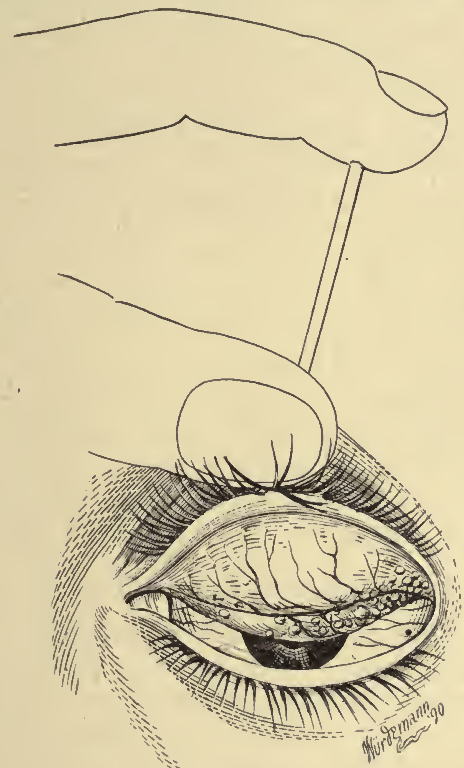

Fig. 357.
How to Expose Fully the Retrotarsal Folds.

the upper lid downwards, and so everts it. One finger of the hand is then made to press the tarsal edge of the lid against the upper part to maintain it in the everted position while the patient looks down so as to expose as much as possible of the inner lining of the lid. A more thorough eversion may be made by pressing down the inverted retrotarsal fold with a blunt instrument, such as a glass-rod or a cotton-tipped probe, whereby all of the retrotarsal fold may be seen, and the foreign body removed by a cotton-tipped brush, forceps, or spud.

Foreign bodies too small or too transparent to be observed with the naked eye, may be removed with a soft brush and the eye subsequently washed out with a boric acid or a salt solution. Illumination may be furnished by a strong convex lens. When examination is difficult on account of photophobia and lachrymation local anesthesia may be induced by a 5 per cent cocain or 1 per cent holocain solution. Since the advent of local anesthesia removal of a foreign body is a comparatively simple procedure.

Particles of coal, cinders and pieces of vegetable matter rarely need instrumental means for their removal. Particles of stone, emery, and metal may be driven into the conjunctiva with considerable force; it is then necessary to dig the body out with a sharp spud or cutting needle, or a gouge. No matter how trivial such injuries may be, there is usually a solution of continuity and pathogenic germs may gain entrance, causing ulceration and inflammatory disturbances which may lead to injury to sight or even to loss of the eyeball. It is therefore advisable in all cases, not only to remove the foreign body but to wash out the eye with an antiseptic solution, and, where the cornea has been in the least abraded, to put on an occlusive bandage.

Conjunctival Injuries from Fire-Arms.

Blasting and dynamite explosions may cause the impaction of a large number of foreign bodies in the conjunctiva, as well as in the cornea, and here it is not only advisable to pick out each individual foreign body from the conjunctiva with the spud, but to seize the membrane and excise by forceps and scissors the carbon stains that are left.

OPERATIONS THAT UTILIZE THE CONJUNCTIVA AS A PROTECTION.

Besides the foregoing operations on the conjunctiva for repair of injuries of that membrane, it is essential for certain conservative operations and especially for repair or protection of wounds and other injuries of the cornea that the mucous membrane should itself be utilized as a protective covering. (1) Plastic operations with the conjunctiva are applicable to all defects in the cornea and sclera which may be rapidly and successfully covered by kerato-plastic and sclero-plastic operations. (2) As protection against prolapses of the ocular contents, especially after excision of iris prolapse and staphyloma. (3) As a temporary shield after trauma from operation.

Schöler[18] in 1886 first recommended the use of conjunctival flaps for keratoplasty and for the protection of corneal wounds. Kuhnt[19]

[18]Schöler. See Michel's *Jahresbericht for 1886.*

[19]Kuhnt. Vorschlag einer neuen Therapie bei gewissen Formen von Hornhautgeschwüren. Weisbaden, 1884; und Ueber die Verwerthbarkeit der Bindehaut in der praktischen und operativen Augenheilkunde, Weisbaden, 1898.

since 1887 has been foremost in the exposition of its use for this purpose. Meyer[20], Snellen[21], de Wecker[22], Bourgeois, Antonelli, Weiss[23], Suker[24] and many others have given their experience and advocated this means of protecting and healing the cornea.

Conjunctiva Plastics for Defects of the Cornea.

Keratoplasty is best accomplished by the use of the conjunctiva, especially in non-infected ulcerations which, when covered by conjunctival flaps, tend to rapidly heal and are not apt to be followed by perforation of the cornea.

After thorough curetting and cauterization the defect is covered by a single or bipedunculated conjunctival flap.

The single pedunculated flap (see the figure) is made by dissecting the sclero-corneal conjunctiva about third around. Then the apex of the flap is cut about 1 cm. wide and an incision made parallel upwards, forming a flap which is then laid carefully over the

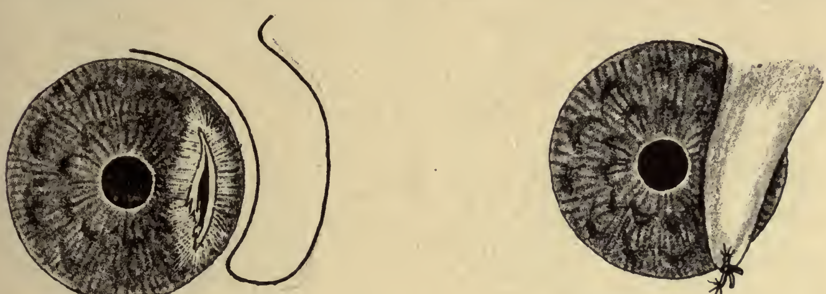

Fig. 358.
Kuhnt's Single Pedunculated Flap.

corneal defect (with or without sutures) and a pressure bandage put over both eyes for from two to four days. The pain disappears in from two to five hours. If the first dressing be made in 24 hours the flap looks like a diphtheritic membrane, on the fifth day becoming intensely red, and in eight to ten days atrophying, so that it appears as a thin membrane over the cornea, which speedily disappears, leaving the ulcerated surface healed.

[20]Meyer. Klinische und experimenteller Beitrag zur Infection vernarbter Irisvorfälle auf endogen Wege. Schutz derselben gegen ectogene Infection.—*Bericht der Ophth. Gesell.*, 1892, p. 109.

[21]Snellen. On the Subconjunctival Treatment of Operative and Traumatic Wounds of the Cornea and Sclerotic. *Internat. Ophth. Cong.*, Edinburgh, Aug. 7, 1894.

[22]de Wecker. Traitément des blessures de la cornée par occlusion conjunctivale, *Ann. d'Ocul.*, CXII, p. 293, 1894.

[23]Weiss, L. Uber die Transplantation brükenförmiger Bindehautlappen zur Decken Ausgedehenter Hornhautdefekte. *Arch. f. Augen.*, XXXIII, p. 311, 1898.

[24]Suker. Kuhnt's Conjunctival Flaps. *Ophthalmology*, July, 1905, p. 650.

With a double peduncle the limbus incision is curved about two-thirds of the way around the cornea and the flap brought straight over the corneal defect, the flap being, as a rule, attached to the limbus. In every case the raw surface left after removal of the conjunctival flap is permitted to heal spontaneously. This takes place through encroachment of the conjunctiva upon the surface, complete healing taking place in about three days.

Two flaps may be used for central defects, one with a single peduncle and the other with two bases, as is shown in the accompanying illustration. They form a cross over the cornea and are secured by stitches, that are removed in five to seven days. The flaps then retract to their former position; or they may be held together in the center by a stitch, the lower flap serving for a keratoplasty.

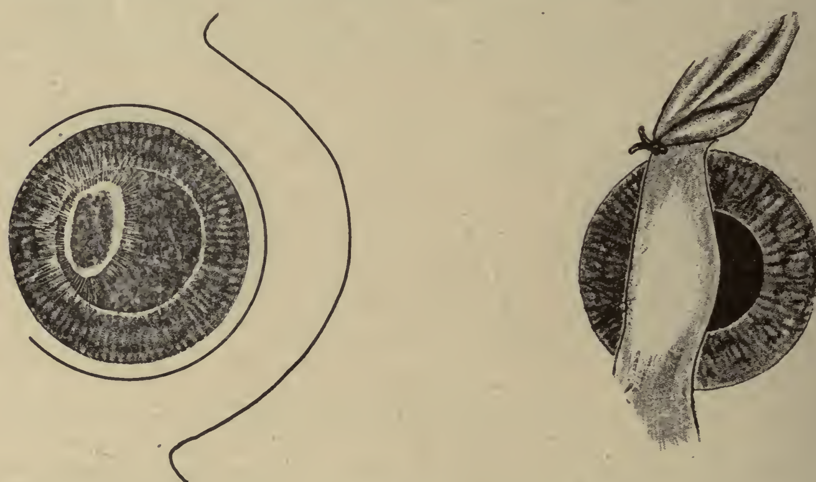

Fig. 359.
Kuhnt's Bipedunculated Flap.

Conjunctival Implantation without Flaps has been tried by Kuhnt[25] and others, but is not as much practised as the method with pedunculated bases. The implantation of conjunctiva, as well as the membrane from the frog's tongue, the vitelline membrane from new laid eggs and the mucous membrane from the lip, has been used by the author in a number of instances with success. The filling in of a large conjunctival defect by Thiersch grafts taken from the skin over the mastoid has been practised by many operators with satisfaction.

For the *healing of ulcers* Kuhnt has given this method an extensive trial, having used it 109 times in deep single ulcers, 67 times

[25]Kuhnt. l. c.

in perforating ulcers, 43 times in marginal ulcers, 7 times in ulcers of a scrofulous nature, in 12 staphylococcus and streptococcus ulcers, in 5 abscesses of the cornea, and in 237 cases of ulcus serpens.

(2) a. *For covering prolapse fistulæ and keratocele* this method eliminates the danger of intraocular infection and prevents ectasiæ.

b. *In old prolapses of the iris.* It is well known that an infection of the globe, resulting in loss of sight or even of the eye itself, may occur as early as eight to fourteen days after an iris prolapse, and by secondary infection at any time during the life of the patient.

Kuhnt[26] states that these are best abscised and covered by a conjunctival flap, and that he secured 46 good results in 49 cases, in none of which did evil results follow, and in but three of which did the iris prolapse reoccur.

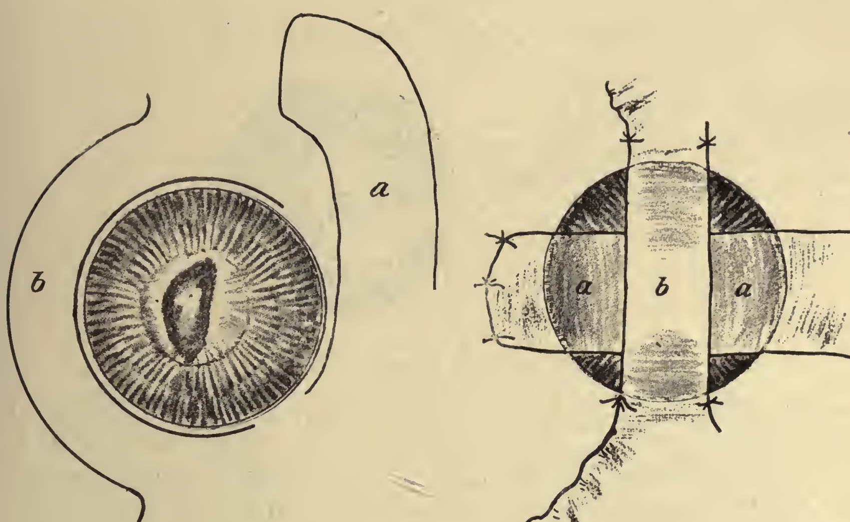

Fig. 360.
Kuhnt Double Flaps.

The operation is conducted by passing a narrow Graefe knife through and under the projection, cutting the cystoid cicatrix on one side, then abscising the flap by forceps and scissors, or by using the Beer's knife for the same purpose. (See figure.) The true iris tissue is not to be drawn out, but the irido-corneal projection smoothed off on a level with the cornea. Then a keratoplasty is done by laying over this opening a conjunctival flap, as before described.

The author has often performed this operation with success. The reaction is not great. The after-treatment is the use of atropin (1 per cent.) to secure dilatation of the pupil; argyrol 50 per cent.,

[26]Kuhnt. l. c., p. 66.

oxycyanide of mercury 1:1,000, or White's salve, (q. v) 1:3,000; or some other preparation of bichloride of mercury. A binocular bandage is then applied and allowed to remain in place four or five days without changing, when on the fourth or fifth day healing is found to have occurred. This is completed on the twelfth day, when the conjunctival flap withers away.

When the iris prolapse is fresh the conjunctival flap method is used as a protective dressing rather than as a keratoplasty.

c. *In Fistula of the Cornea.* The danger to the lens of opacification, to the iris of prolapse, and to the globe of infection or atrophy and phthisis bulbi from a fistula of the cornea may be obviated by freshening the edges of the ulcer and applying a double, pedunculated keratoplasty by the conjunctival flap method. Healing and permanent closure occurs in 12 to 14 days.

d. *Keratocele* is to be treated by puncture with the point of the

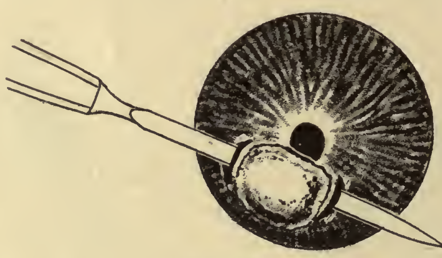

Fig. 361.
Abscission of Cystoid Cicatrix.

knife, excision by forceps and scissors, and a double pedunculated flap. Healing results in 10 to 12 days.

e. Kuhnt also recommends the operation for *incipient staphyloma of the cornea,* excising with the corneal trephine or burning with the galvano-cautery the protruding scar tissue and then laying over it a conjunctival flap.

Use of the Conjunctiva in Ocular Injuries.

Covering gaping wounds of the sclera and cornea by means of conjunctival flaps is essential to proper healing. One sees its value in the use of a sclero-corneal conjunctival flap for all operations for cataract or upon the iris. This method of operating is advised by many authorities and is my personal preference. Prevention of infection is also secured by immediate closure of the wound and is, indeed, essential where a chronic conjunctivitis or lachrymal suppuration is present, even when the corneal wound is superficial.

In *penetrating wounds of the sclera,* after careful exploration and removal of impacted and extruded uvea and snipping off the protrud-

ing vitreous, the sclera should be stitched with one or two interrupted sutures of catgut. A conjunctival flap is then pulled down over the wound so that the cut sclera and cut conjunctiva be not in apposition—as pictured in the text.

In *penetrating corneal wounds* the procedure is more difficult, the character of the conjunctival flaps varying from single and double

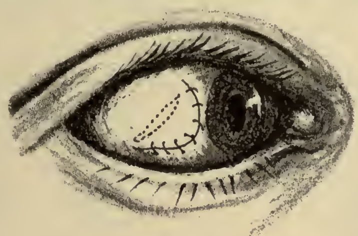

Fig. 362.
Conjunctival Flap over Scleral Wound.

pedunculated (or double flaps as above described) to the dissection of a large part or all of the conjunctiva at the limbus and connecting its cut edges by three or four interrupted stitches, as advised by de Wecker; or by a pouch suture, pulled tight to cover completely the cornea, as used by the author and shown in the figures.

This use of the ocular conjunctiva is for protection rather than keratoplasty. In about five days, after the corneal wound has suffi-

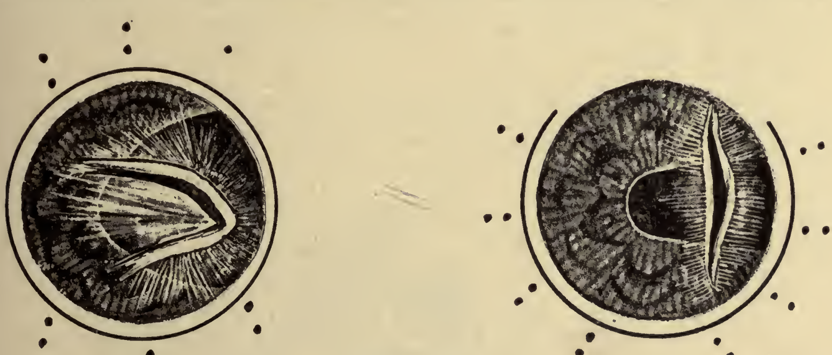

Fig. 363.
de Wecker's Temporary Conjunctival Covering of Cornea.

ciently coapted, the sutures may be cut and the conjunctiva allowed to retract to its place at the limbus. Here it heals, and in a couple of weeks there is no trace of its ever having been divided.

In complicated wounds of the anterior segment of the eye the prolapsed iris should be abscised, and if the lens capsule be injured and the body of the lens be broken up, the lens substance should be released and a careful toilet of the wound made.

In *complicated wounds of the sclera* the protruding uvea and vitreous must be cut off and the wound cleared of debris before the sclera is sutured.

In operative procedures, especially in cataract, Kuhnt first dissects and loosens a bridge of conjunctiva above the cornea, then performs a corneal incision, completes the delivery of the lens, brings down the conjunctiva over the wound and sutures it by two inter-

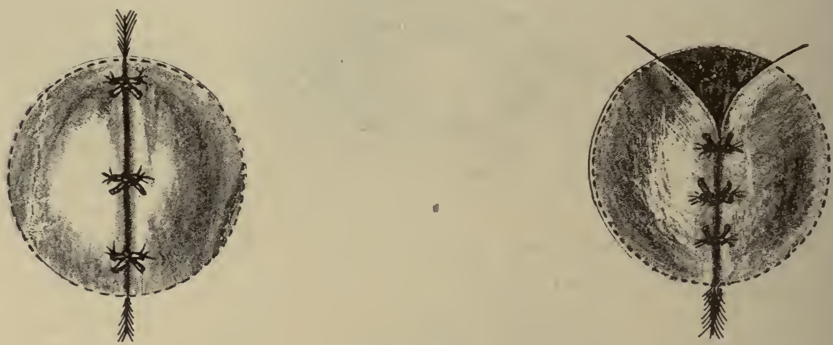

Fig. 364.
de Wecker Temporary Conjunctival Covering, Sutures Tied.

rupted stitches at the limbus. The same operation may be done to cover the wound after iridectomy.

Maddox personally communicates the following modification of his conjunctival flap operation, under the title *Lattice Suturing of the Conjunctiva,* after severe injuries in the ciliary region:

"The usual mode of covering wounds of the corneal limbus with conjunctiva is insufficient when a penetrating wound extends far into both the cornea and the sclera. In these cases, after thorough disinfection and re-

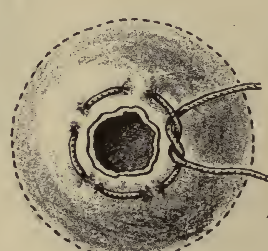

Fig. 365.
Author's Pouch Conjunctival Suture.

moval of any prolapse, and after also delicately touching any doubtfully aseptic tissue with a fine electro-cautery, I undermine a large flap of conjunctiva beyond the wound, and draw it upwards by means of one long silk suture passed alternately through the conjunctiva above the cornea and the margin of the raised flap, several times. It is remarkable how the cornea tolerates the presence of the sutures and by the multiple strands the tension in each is so much lessened as to be inconsiderable.

"The security is immensely greater than that afforded by the usual

plan of stitching up merely the two corners of the flap so as to avoid the cornea. I do not know if this little proceeding is original, but I have by its means saved one eye at least, otherwise only suitable for enucleation.

"The direction of the sutures should of course be so planned as to make the best of the flap of conjunctiva. For example, if there be a deep cut or notch in the conjunctiva over the injury, the sutures should be

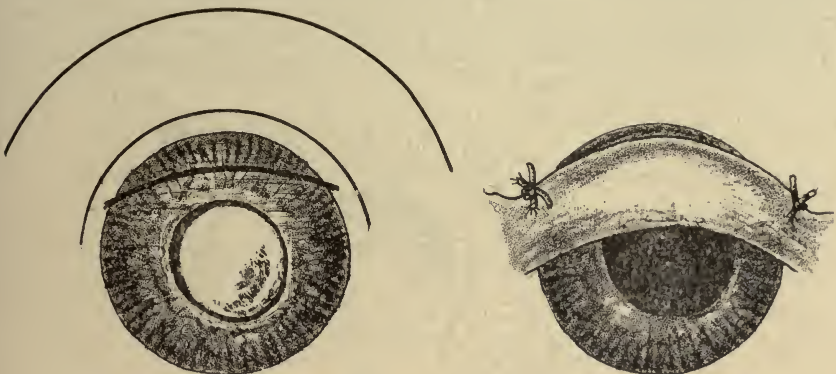

Fig. 366.
Kuhnt Bipedunculated Flap for Cataract Extraction.

made to run obliquely and the undermining of the conjunctiva be more on one side of the wound than on the other, that the conjunctival gap should not be radially coincident with the injury; as shown in the illustration. The notch may, if necessary, be itself stitched up first. The silk sutures chosen should be soft and not too thin. The strand indicated in the diagram by 'a, a' supports the base of the flap and lessens the traction of its margins."

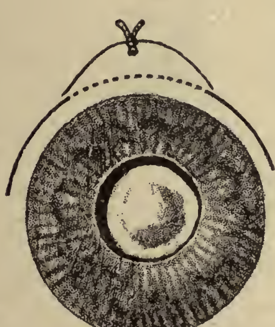

Fig. 367.
Conjunctival Flap for Cataract Extraction.

Fig. 368.
Lattice Suture of the Conjunctival Flap over Extensive Penetrating Wound of Cornea and Sclera. (Maddox).

Koyle[27] describes the following operation for repair of a descemetocele of the cornea:

[27]Koyle. Repair of the Cornea. *Ophthalmology*, July, 1910.

"After thorough local anesthesia, two incisions, with a narrow bridge between them, are made in the conjunctiva about 1½ mm. from the recently repaired corneal margin and extending from below upward to a point a little above the horizontal diameter. The conjunctiva is then dissected back towards the equator for a distance of about 7 or 8 mm., leaving a triangular portion untouched at the lowest point on each side. An elliptical incision is then made at the limit of the dissection, thus affording two long, broad flaps, which are brought across transversely, trimmed and sutured. In making these flaps great care is taken to secure a proper degree of tension and a perfect approximation of their edges. A longitudinal incision is

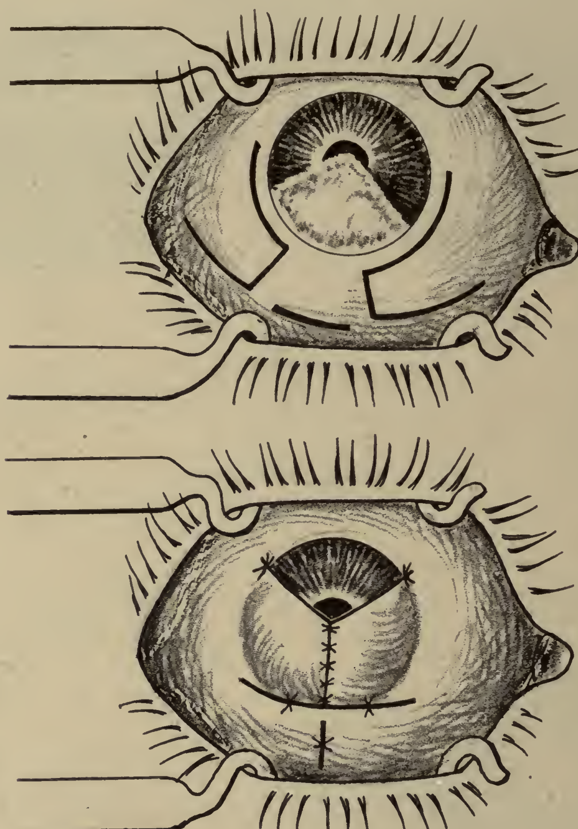

Fig. 369.
Modified Kuhnt Keratoplasty. (Koyle.)

then made well below, and the conjunctiva above and below loosened. This newly-made band is stitched on either side to the conjunctiva left at the edge of the cornea, and the lower edge of the flaps tacked to the same narrow strip.

The quadrilateral surface exposed by this procedure is covered by passing a suture through the lateral angles and drawing them together, thus reversing the line of incision. Anchor sutures are then placed on each side of the cornea superiorly, lifting the upper edge of each flap to a point well beyond the denuded portion of the cornea, care being used to prevent undue tension on the flaps above or below. (See the drawings.)

J. Edgar Deane writes the author as follows:

"*Double Suture of a Wounded Eye.*—I have saved the eyeball where it had been slit for at least an inch across the cornea and sclera by a flying piece of iron, accompanied by escape of all the aqueous and, perhaps, half the vitreous, by making use of a double set of fine catgut sutures; first suturing the sclera and then the conjunctiva separately. Of course the latter could just as well have been done with silk. As in each case the ciliary region was injured traumatic cataract ensued within a month, although the lens itself seemed uninjured at the time. The result in each case was a natural eye of good appearance and with only a linear scar."

SURGICAL TREATMENT OF CORNEAL INJURIES.

Wounds. Small and non-penetrating wounds of the cornea need no operative treatment unless infected, as they generally heal under *simple* asepsis. If the wound is not infected and is well cleared of iris prolapse and tags of tissue, if it coapts well, as in the incision made in cataract extraction, it speedily heals and does not need suturing.

Fig. 370.
Corneal Suture.

However, when the wound gapes and promises delayed healing, when there is loss of substance and when the wound is irregular, angular or flap-shaped, or when one edge is rolled inwards or outwards or has been changed in position, a sterilized stitch may be needed, although in most of such cases the use of the conjunctival flap is the preferable procedure.

Corneal Suture. The suture and needle are placed only through the external layer of the cornea (about one-half its thickness) 0.5 mm. from the edge. After pulling the edges of the wound together a square knot retains them in place for five to seven days, when the suture is snipped by the scissors and removed with forceps. As a rule corneal sutures are well borne and have been used by me many times with good results. Eversbusch[28] and Czermak[29] recommend

[28]Eversbusch. Ein casuistischer Beitrag zur Behandlung der penetrender Quetsch und Schnittwunden der Hornhaut und Loderhaut. *Münch. Med. Woch.*, 1891, p. 487.
[29]Czermak. *Augenärztliche Operationen*, 2nd Ed., Vol. II, p. 64.

them highly. However, such corneal sutures may not be well tolerated, as shown by Adamuck.[30]

Cauterization of Corneal Ulcers Following Injuries.

The cauterization of corneal ulcers is especially a conservative operation by which many wounds and ulcers dooming the eye to perdition are thereby cleaned out and caused to rapidly heal. Chemical cauterization is done by phenol 95 per cent solution on a small cotton-tipped stick, fused rod of silver nitrate or fused bead of trichloracetic acid after local anesthesia by cocaine, alypin or holocain.

More satisfactory cauterization and cleansing of the ulceration is, however, afforded by the actual cautery which was first recommended by Martinache[31] for this purpose, but probably used from ancient times.

Platinum-pointed cautery instruments, which may be heated by the alcohol lamp and are very convenient, have been devised by Simeon Snell, Frank Todd and others. (Compare the illustrations.) The galvano-cautery with miniature tips as devised by Knapp give a va-

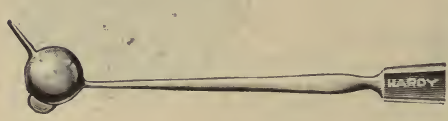

Fig. 371.
Todd's Corneal Cautery.

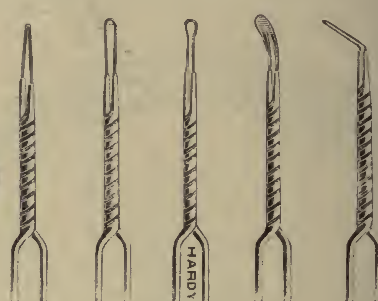

Fig. 372.
Knapp's Galvano Cautery Electrodes.

riety of tools for selection. After the extent of the ulcer is defined by staining with a 20 per cent potassium bicarbonate fluorescin solution, which stains the eroded area a brilliant green, the cornea is anesthetized by cocain, alypin, or holocain, the conjunctival cul-de-sac disinfected by flushing with a feeble antiseptic, as a boric solution. The lids are held open by a stop speculum and the deeper parts of the ulcer, its whole base and its edges, cauterized by a dull-red heat. A dry, brownish eschar is immediately produced which is thrown off in a few days, leaving a healthy granulation tissue. The after-treatment is by washing out the conjunctival sac three times a day, instillation

[30] Adamuck. Zur Frage über die Anlegung von Suturen bei Hornhaut-Wunden, *Westnik. Oph.*, 1892, I, p. 16.

[31] Martinache. Ulcer of the Cornea, treated by the galvano-cautery. *Pacific Med. and Surg. Journ.*, Nov., 1873, p. 294.

of atropin and dionin, applications of powdered iodoform, bichlorid salve, and light bandaging, if the open method of treatment be used. Otherwise, as previously described, the area of ulceration may be covered over by conjunctival flaps.

Keratotomy, or the Saemisch Section.

This operation, more properly bearing the name of the British surgeon G. J. Guthrie (see Corneal Operations), is indicated in hypopyon ulcer, being made after preparation as for cauterization. A stop speculum is used, the eye fixed by forceps, and a Beer's triangular knife passed through clear corneal tissue at the base of the ulcer, through the ulcer and out through the other side, the point coming out 1 mm. from the edge of the ulcer in clear tissue. A von Graefe knife may be used for the same procedure. The hypopyon is pulled

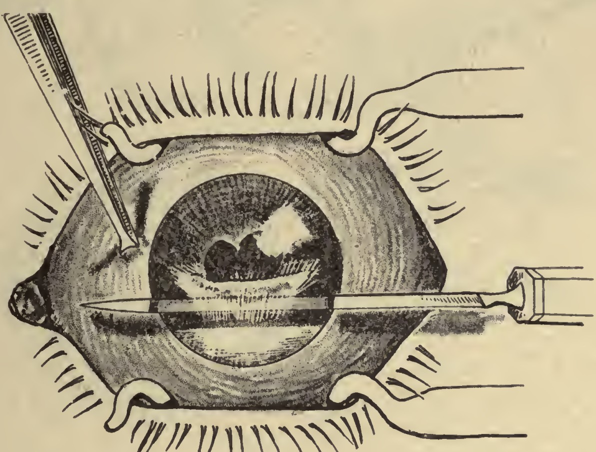

Fig. 373.
Keratotomy or Saemisch Section, in Hypopion Ulcer.

out by forceps or removed by syringing. A Haab iodoform disc or rod is then placed within the anterior chamber, or a 50 per cent argyrol solution injected therein, after which the lids are closed and bandaged. Daily cleansing of the eye by weak boric solution and removal of any protruding hypopyon by forceps, by reinjection of argyrol solution into the anterior chamber if it still be open, and into the conjunctival cul-de-sac, may save the eye.

As a rule it is here inadvisable to excise any portion of the iris as the lymph spaces in the iris may thus be opened up to further channels of infection, and panophthalmitis may thereby occur. The iris always prolapses after this operation and leucoma adherens is thus produced.

Since the advent of electrical cauterization the Saemisch section

is rarely performed. Rollet drains the anterior chamber in hypopyon by placing a horse-hair through a puncture in the lower part of the cornea.

Flushing of the anterior chamber with normal salt solution (9/10 of 1 per cent) or 3 per cent boric acid may be used after an incision through the ulceration or by the wound of entrance made by the for-

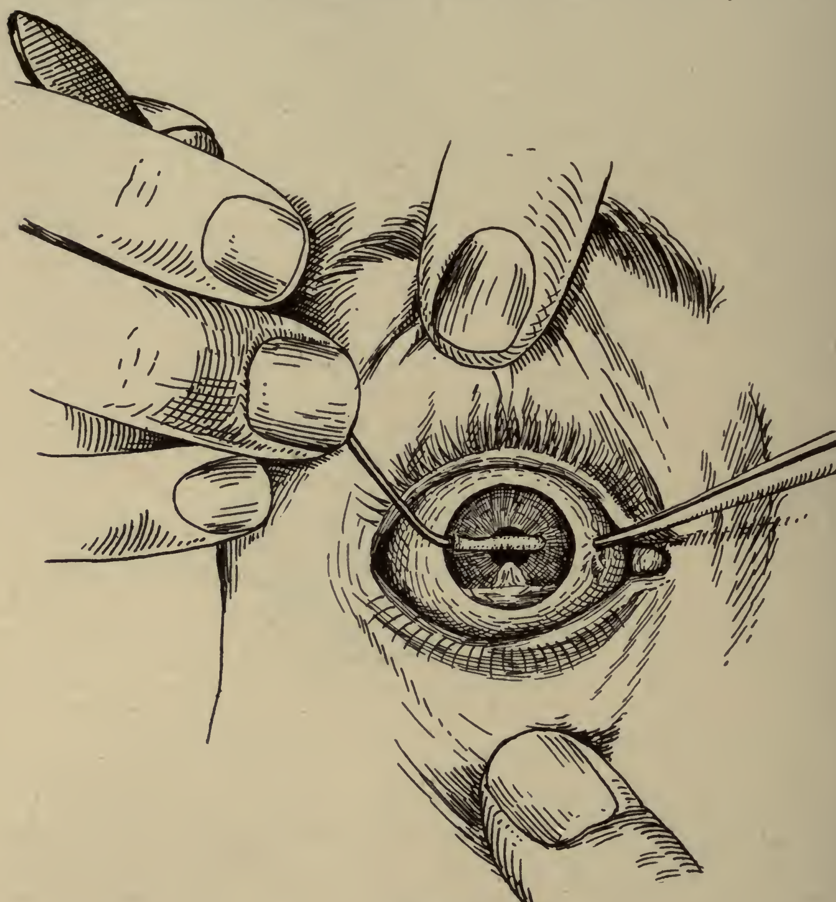

Fig. 374.
Introduction of a Pencil of Iodoform Into the Anterior Chamber in a Case of Infection by a Foreign Body.

eign body. The Lippincott or McKeown irrigator, a curved pipette, the undine, and the Todd or Elwood wash-bottles carry the stream of fluid gently into the anterior chamber. The iodoform rod or discs of Haab[82] may be introduced by forceps into the anterior chamber; the argyrol solution by curved pipette.

[82]Haab. *Operative Ophthalmology*, Amer. Ed., Plate I, 1905.

Subconjunctival injections of mercury and normal salt solutions was brought forth, as before stated, by Darier and recommended for years by him and others as of the utmost benefit in cases that do not respond to other treatment. A stop speculum and fixation forceps are commonly used, although not necessary with a quiet patient. The eye is first rendered insensitive by a local anesthetic, half a hypodermic syringeful of 1:5,000 cyanide, bichloride, or iodide of mercury solution is injected under the conjunctiva, the needle of which is inserted well under the tissue back of the limbus between the recti muscles. This raises the conjunctiva in a bleb over the globe. Massage with

Fig. 375.
Lippincott Irrigator for Anterior Chamber.

the finger tips is then made and a light bandage applied for 12 to 24 hours.

Perforating injuries of the cornea are almost invariably complicated by prolapse of the iris, which has been ascribed by Tooke* as an effort of Nature at repair, for the iris fills the opening, stops the wound, becomes adherent, and forms a sort of misdirected healing and the development of a high degree of irregular astigmatism. The scar later becomes cystoid, ectatic, and produces increased intraocular tension which may lead to blindness and hence excision of the prolapsed iris is to be made. Prolapse of the iris likewise occurs in rupture of the cornea and sclera.

Foreign Bodies on and in the Cornea.

The larger percentage of foreign bodies on and in the cornea

*Tooke. On the Protective Influence Exerted by the Iris in Perforating Wounds of the Cornea. *Ophth. Record*, Aug., 1908, p. 386.

come under the heading of motes in the eye. Trivial injuries from small intruders cause but little erosion of tissue which rapidly heals if the foreign bodies are speedily removed. The character of these objects is variable and depends upon the locality, in manufacturing cities being emery or metal particles, in others, cinders, stone and particles of herbage, and in farming communities husks of seeds, wood, etc. They may be denominated as (1) lying on the cornea, not firmly attached; (2) burned into the cornea, as cinders, sparks, emery; (3) metal chips, stone, etc.

Fig. 376.
Würdemann's Lamp and Transilluminator.

For the removal of foreign bodies in the cornea, the patient is seated in a good light facing the source of illumination, or having it reflected upon the eye by the head-mirror, or focused by oblique illumination through a lens held by an assistant, or by the patient himself, as recommended by Thorey[33], (1), or by the ocular illuminator of the author, or even par excellence by the electric lighted spud of A. C. Snell.[34] The binocular loup of Berger or Jackson aids in the recognition of the object, which is brought into view by a 2 per cent sodium bicarbonate fluorescin solution, which stains the abraded surface a

Fig. 377.
Snell's Electric Lighted Spud.

brilliant green, forming a bright-green background against which the object is in relief.

The surgeon may stand in front of or behind the patient, as he prefers. The latter should be seated with his head in a rest, or, in an emergency, backed against the wall, as the custom of the "mote remover" of Sheffield and other manufacturing towns. In quiet patients superficially lying foreign bodies may be brushed away by a cotton-tipped stick or tooth-pick without a local anesthetic. In most cases,

[33]Thorey. Ein Hilfsmittel zur Entfernung von Fremdkörpern. *Klin. Mon. f. Aug.*, XLVII, Sept., 1909, p. 319.

[34]A. C. Snell. An Illuminated Spud. *Ophthalmology*, July, 1908, p. 642.

however, numbing the tissues by cocain 5 per cent, alypin 2 per cent, or holocain 1 per cent is advisable. Even dropping clean, cold water into the eye will afford a slight anesthesia sufficient to allow of a foreign body being brushed away.

In shops of the iron and steel trades where many trivial accidents happen to the eyes daily, as Simeon Snell[35] says, "in the proportion of one accident to one workman a year," the workmen should be instructed to use a wisp of cotton rolled on a tooth-pick and to dispense with the pin, knife-blade, horse-shoe nail, etc., or instruments of any kind, contenting themselves with simple efforts to remove the foreign body with the cotton twisted on a stick, which can do little or no damage, and to let the oculist attend to those cases in which the foreign body is thus not immediately removed. Even the general practitioner would be wise to do little more when the services of an oculist

Fig. 378.
Berger's Binocular Loup.

are available, for the usual history of cases reaching the oculist is that some of the mechanics at the shops have first tried to remove the foreign body with not infrequent infection from unsterilized instruments, and further abrasion of the corneal epithelium with infection and ulcer. The worst cases we have to do with are those that have been unskillfully handled by the patient's mates at the shop, on the road, or by some physician whose eyesight and manual dexterity are not sufficient to remove the foreign body without causing more damage to the eye than if it had been left alone.

Some of these cases do not call for skillful assistance until several days have passed and a slough has formed in which the foreign body is not visible, and here special instruments are necessary to re-

[35]Simeon Snell. *On the Prevention of Eye Accidents Occurring in Trades*, London, 1899.

move the foreign material, including the sloughing ulcerating area, as described in the next paragraph.

(2) In the operation for removal of *objects impacted or burned* into the cornea, in but few cases is the foreign body so loosely held by the tissues as to be removed by brushing. The patient's eye is then prepared, and he is placed in the same position as in the foregoing, the lids held apart by the operator's fingers or those of an assistant, or in a few cases a stop speculum may be needed to restrain the wincing and blepharo-spasm of the patient. The pointed instrument sold as a foreign body remover or spud is not generally satisfactory. A grooved miniature gouge, such as I first obtained in Vienna in 1888, or as described by Todd[36] in 1906, does not permit the foreign body to slip off and it therefore may be scooped out. The cornea is at least 1 mm. thick and quite tough, so the careful surgeon may do considerable digging with an instrument without perforation. The sharp curved gouge may be rotated between the fingers around the foreign body, taking out a core of the cornea and with it the intruder. Iron and emery stains are especially to be thus treated.

Particles of powder are very difficult of removal and need not

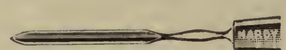

Fig. 379.
Todd's Foreign Body Instrument.

be dug out except for cosmetic reasons, or if they are in the line of vision, as they are aseptic and do not cause irritation, becoming covered with new tissue. They may be successfully burned away by a small galvano-cautery point, but the surgeon should be an expert in order to do this delicate operation without damage to normal tissue.

(3) In the case of *deeply-penetrating* foreign bodies, as metal splinters, particles of sand, stone, etc., the spud must be carefully used; even if the foreign body be of magnetizable metal, the magnet is of no assistance except perhaps to demonstrate the quality of the object after its removal.

If the cornea be perforated and yet the foreign body remain within the wound the injury becomes a complicated one, involving the anterior chamber and perhaps the iris and lens, together with a risk of infection, the formation of cataract, etc., and the foreign body might be pushed within the eye in efforts at removal. Here one should pass a lance or a Graefe knife through the cornea, holding the blade against the inner surface, thereby retaining the foreign body in position while it is cut down upon from without by the knife point, spud, gouge, or other instrument, and then removed.

[36]Todd. *Railway Surgical Journal*, August, 1906.

Powder and dynamite explosions may lead to impaction of particles of lead, small shot, sand, stone, or other small foreign bodies in the cornea which may be picked out as in the foregoing.

The removal of metallic oxides, especially lead incrustations in the cornea, is by simple curettement of the epithelium under local anesthesia, and then applying to the tissue by means of cotton pledgets a 3 to 5 per cent solution of iodide of potash, as advised by Fernandez[37]. Schiele[38] immediately follows this up by a 3 to 5 per cent solution of iodic acid, the lead albuminate becoming a soluble iodate as the incrustations become dissolved, being removed by mechanical means.

INJURIES TO THE SCLERA AND CORNEO-SCLERAL MARGIN.

Non-perforating Wounds.

Superficial, non-perforating wounds of the sclera are of little moment and heal quickly if the conjunctival wound, which is always coincidental, be closed over them, so a simple stitch or two bringing the edges of the conjunctiva together insures good healing.

Perforating Wounds.

Only at the corneo-scleral margin can perforating, but not deeply-penetrating, wounds of the sclera occur without involving the uvea, retina and the vitreous; or the cornea, iris, and lens. Penetrating wounds of the posterior part of the eyeball pass through the conjunctiva and sclera, and involve prolapse of the intraocular contents. These wounds are most successfully treated by the conjunctival flap method with or without scleral stitches.

The Scleral Suture.

All scleral wounds over 3 mm. in length are apt to gape and allow of extrusion of the intraocular contents. One, two, or more of the finest catgut, kangaroo, or rat-tail tendon interrupted sutures threaded on very sharp, moderately curved needles should be placed through the lips of the scleral wound and its edges carefully adjusted, care being taken not to lose more vitreous. The lips of the wound should be seized by toothed forceps and, the needles being sufficiently sharp, the central sutures are first taken and loosely tied. They are snipped close to the knots and a flap of the conjunctiva dissected up and sutured in place by interrupted iron-dyed silk sutures, the line of the conjunctival stitches passing outside of the sclera. The stitches in the latter should be buried and allowed to absorb, those in the conjunctiva being removed about the fifth day. These operative steps are pictured in the illustration.

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[37]Fernandez. *Arch. d. oftal.*, Oct., 1906.
[38]Schiele. *Wochenschr. f. Therap. u. Hyg. d. Aug.*, No. 34, 1904.

Injuries at the Ciliary Region.

Here we have to choose between the radical removal of a badly injured eye, which as a rule prevents the patient from working for a long period of time or subjects him to the danger of subsequent sympathetic ophthalmitis, and the conservative efforts to preserve the globe with more or less sight.

Immediate enucleation or one of its substitutes should be done in all badly-lacerated injuries of the ciliary region, particularly if infected or if 20 per cent of the vitreous has been lost, when no sight can be expected, especially in the case of working men, who cannot afford the loss of time or expense ensuant upon the conservative haning of the case; and in other cases liable to pass from observation.

Conservative treatment and operations are proper in clean-cut and incised injury cases, particularly in the eyes of the upper classes, when the realization of the risk of sympathetic disease may be brought home and the patient kept for a long time under observation.

Of special importance besides asepsis and antisepsis in the cleansing of the wound is the removal of prolapses of the interior, the iris by iridectomy, the chorioid and vitreous by abscision, and the careful toilet of the wound followed by scleral and conjunctival suturing and conjunctival flaps.

I am sure that I have saved many eyes from infection by the injection of 50 per cent argyrol solution into the conjunctival sac and into the anterior chamber, the latter through the accidental wound even where evidences of infection, as iritis and hypopyon, were already evident. The 1:3,000 bichloride vaseline ointment of White as a dressing to the lids prevents the entrance of micro-organisms and kills off the streptococcus endemic to the tarsus.

The next indication is iridectomy for the prolapsed iris. It is usually useless to attempt to replace a prolapse, as it only recurs, becomes impacted and results in a cystoid cicatrix with its resultant dangers. It is good then to seize the iris by delicate forceps and by gentle traction withdraw it a little, snip it off and complete the toilet of the wound by replacing the pillars within the anterior chamber. It is not always necessary to excise the iris to the ciliary margin, only the protruding part may be removed. Protruding portions of the choroid and ciliary body should not be excised unless penetrated, on account of the possibility of loss of vitreous and infection of the globe. Prolapses of the vitreous should be snipped off even with the globe before sewing up corneo-scleral or scleral wounds.

Old cystoid cicatrices may be dealt with by the galvano-cautery, the outgrowth being seared evenly with the surface of the globe, then

antisepsis, atropin and a bandage applied. I have cut off and seared by the cautery a number of such protrusions without causing special irritation.

Foreign Bodies in the Sclerotic.

Praun[39] says that foreign bodies in the sclera occur about 200 times less frequently than in the cornea. Medium-sized foreign bodies sticking in the sclera, after cocainization of the eye, may be seized with forceps and pulled out. Others have to be cut out by the gouge and knife, forceps and scissors, care being taken not to push the foreign body into the interior of the eye. In the case of iron objects the magnet may be first tried or used as an adjuvant after loosening the foreign body. If it cannot be removed without too much dissection on the first attempt it is better to wait a few days and then try again. Powder grains and stains and grains of sand may be cut and scraped away after incising the conjunctiva.

Ruptures of the Sclera.

Either from direct or indirect violence these are usually severe and cause much loss of the ocular contents, so that enucleation is frequently inevitable. In rare instances it may be partial and even the lens may be extruded by the trauma with retention of vitreous. The lens is frequently found under the conjunctiva, which may not be ruptured. In very favorable cases the eye heals in four to six weeks and the wound fills in with scar tissue.

The first duty of the surgeon is to cleanse the injured eye, bandage both, apply cold applications, put the patient to bed, and in about 48 hours remove the iris prolapse, put in scleral stitches, and sew a bipedunculated conjunctival flap over the wound.

The after-treatment is that of perforating wounds of the sclera and sclero-corneal margin. If the lens be retained under the conjunctiva it should be removed by a conjunctival incision. Cataract may be dealt with later by the usual methods.

Scleral Sutures.

Baretti[40] in 1833 first described suturing of the sclera in a wound, one cm. long, caused by penetration of the eye by a splinter of glass. Bowman[41], Critchett, Windsor[42], Lawson[43] and others in past decades used this procedure with good results. In all wounds of the

[39]Praun. *loc. cit.*, p. 213.

[40]Baretti. *Gazette Italienne des ētats sardes*, 1833.

[41]Bowman. Quoted by Czermak.

[42]Windsor. Treatment of Wounds of the Eye by Suture. *Royal Lond. Ophthal. Hosp. Rep.*, 1871, p. 397.

[43]Lawson. Punctured Wound of the Sclerotic with escape of Vitreous, treated by closing the wound with a suture. *Royal Lond. Hosp. Rep.*, 1871, p. 14.

sclera it is necessary to replace or remove tags of tissue therefrom in order to secure good healing. In the olden days these cases were usually treated only by the bandage and rest, but many such were followed by ectasiæ and infection and hence the suturing of such wounds was taken up.

When the wound is sectoral and does not gape its closure by conjunctival suture is advised by Simeon Snell[44] as the operative procedure needed aside from the toilet of the wound. In gaping tangential, or meridional wounds sutures of catgut should be used—through the sclera, either through the outer layers where the sclera is thick, as formerly used by Lawson[45] or, when thin, through the whole thickness, as advised by Czermak[46].

Fage[47] sums up the advantages of the scleral suture: 1. It protects the interior of the eye from infection. 2. It hinders the further loss of vitreous. 3. It prevents the formation of fistula, cystoid cicatrix and staphyloma. 4. It causes the formation of a much more regular and flat cicatrix, and the probability of secondary retinal detachment is less. 5. It shortens the healing period.

Eversbusch[48] recommends the suture even in central contused and lacerated wounds when not infected. Czermak[49] gives the following contra-indications for the scleral suture: 1. Severe, and especially deeply-penetrating wounds with extensive loss of vitreous, threatening entire loss of the intraocular contents, extensive bleeding into the vitreous cavity, and when the eye is so severely damaged that its removal is immediately indicated. 2. When a foreign body remains which cannot be removed from the globe. 3. When appearances or course point to inflammation of the globe. 4. Fage[50] also gives the following as a contra-indication for the suture: When in the case of a scleral rupture the conjunctiva has not been torn open.

Czermak[51] does not agree with the latter contra-indication, as under modern asepsis wounds should heal well without infection and a gaping conjunctival rupture would allow of prolapse of intraocular contents and therefore, especially when the lens has been dislocated, it is necessary to remove the lens from the conjunctiva and sew up the wound.

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[44]Simeon Snell. On the Closure of Wounds of the Sclerotic by suturing the Conjunctiva only by silk threads. *Oph. Review*, 1887, p. 88.

[45]Lawson. *Injuries to the Eye, Orbit, and Lids*, Phila., 1867.

[46]Czermak. *Augenärtzlichen Operationen*, p. 691.

[47]Fage. Résultants immediats et tardifs de la suture scleroticale, *Ann. d'oc.*, 1894, p. 262.

[48]Eversbusch. Ein casuistischen Beitrag zur Behandlung der pentrinenden, Quetsch-und Schnittwunden, der Hornhaut und Lederhaut. *Münch. Med. Woch.*, 1891, p. 487.

[49]Czermak. l. c., p. 690.

[50]Fage. l. c.

[51]Czermak. l. c.

The needle and suture operation is made as in the case of corneal suture under local or general anesthesia, the edges of the wound being held by fine forceps, or, as Kerzendorfer[52] advises, by a fine hook, but I prefer the forceps. If the conjunctiva be torn or wounded at the same place the needles and threads may pass through the conjunctiva or episclera, when silk may be used. If the conjunctival wound is at another place the sutures should be of catgut or tendon and the conjunctival suture of silk.

Lawson in 1871 and other authors up to Czermak in 1907 recommended double-armed sutures, i. e., with a needle on each end passed through the lips of the wound edge out and then tied. In some cases

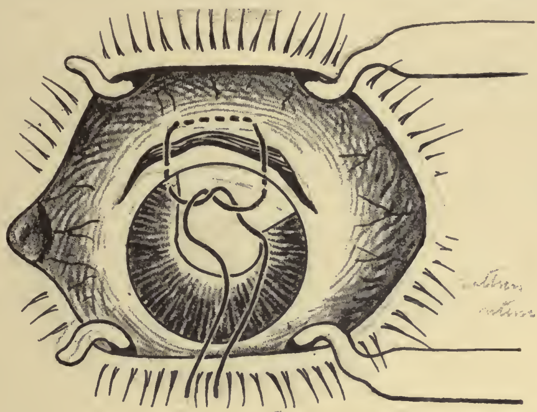

Fig. 380.
Author's Mattress Suture.

I have used the mattress suture, made by passing the first needle of the double-arm suture from without towards the lower lip of the wound, through the corneal or episcleral substance, then across the wound again into the episclera into the upper lip, then pass it at right angles under the conjunctiva about 1 cm. away, re-entering the episclera of the lip of the wound, crossing over, entering the scleral tissue again behind the lower lip of the wound. The wound then being approximated by forceps the knot is tied on the surface of the cornea.

Another kind of retaining or tension suture has been advised by Nuel[53] for corneo-scleral ruptures and after sclerotomy for cystoid cicatrix. A double-armed suture is passed under the conjunctiva, about 2 cm. long, behind the wound about the equator of the globe, then crossed over the wound to the inner side, being tied below. These

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[52]Kerzendorfer. Zwei Fälle von penetrerenden Wunden der Sclera. *Arch. f. Aug.*, 1878, p. 44.

[53]Nuel. Des ruptures sclero-cornéennes. *Ann. d'oculistique*, 1888, p. 270.

sutures (see figure) may be removed about the fifth day, when the wound will be found to have sufficiently coapted.

The treatment of sequelæ frequently sums itself up in enucleation or one of its substitutes. Cystoid cicatrices may be ablated by the cautery or various operations done for ectasiæ.

Landesberg[54] ablates a scleral ectasia by repeated corneal incisions, even to seventeen sittings, but, as this method is very wearisome to the patient, recommends the excision of a section 1 to 2 mm. in width, the result being the formation of a thickened cicatrix which conserves the normal form of the globe.

Eversbusch[55] recommends many small punctures by the galvanocautery.

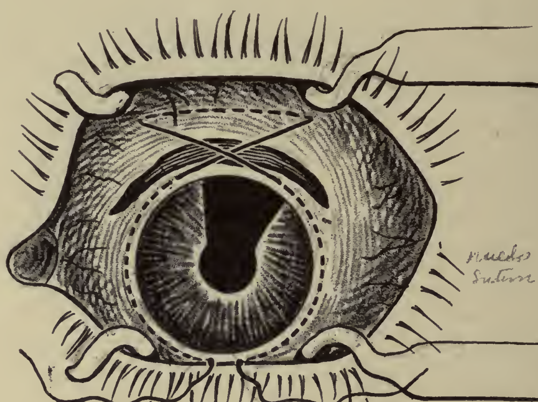

Fig. 381.
Nuel's Suture for Scleral Rupture.

Thermal Injuries. The treatment of burns and cauterizations is that of the conjunctiva, lids, and cornea.

THE UVEAL TRACT.

Wounds of the iris are treated by atropine and antiseptics for the external wound.

Prolapse and inclusion of the iris in the corneal and scleral wound are accompanied by evil consequences of many kinds, and this suicidal attempt of this membrane to restore the anterior chamber, while it prevents immediate infection according to Tooke[56], interferes with the healing of the wound and causes protraction of the time of heal-

[54] Landesberg. Zur Behandlung der Scleralstaphylome traumatischen Ursprungs. *Archiv. f. Augenheilk.*, XVII, 2, 1886, p. 202.

[55] Eversbusch. *Münch. Med. Woch.*, 1891, p. 487.

[56] Tooke. On the Protective Influence exerted by the Iris in Perforated Wounds of the Cornea. *Ophth. Record*, Aug., 1908.

ing. Therefore, every attempt should be made to avert such an occurrence.

If required, an attempt at reposition of the iris prolapse may be made by replacing it with the spatula, either through the wound opening or through a cut in the cornea made some distance away from the wound. In the latter case the second opening equalizes the outflow of aqueous and permits the pupil to resume its circular form, but as a rule iridectomy is the only safe procedure, as a prolapse is with difficulty replaced and even harder to retain within the anterior chamber. Therefore the prolapsed iris should be seized by delicate forceps, slight traction being made, and the projecting portion abscised, after which the pillars are replaced by the spatula and the toilet of the wound completed.

John Dunn[57] makes a corneal incision through which a blunt iris hook is passed, making traction on the incarcerated iris, drawing it back into the anterior chamber.

Prolapse of the iris is a common complication of perforating and penetrating wounds of the anterior portion of the eyeball, with or

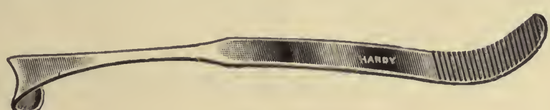

Fig. 382.
The William Fisher Lid Elevator.

without the entrance and retention of foreign bodies. All operations opening the anterior chamber involve a risk of this event, so that iridectomy is in many cases made a part of the operation, as in combined cataract extraction, removal of foreign bodies, etc.

The treatment of iridic prolapse was formerly either entirely expectant, the eye being bandaged and left to natural resources; or it was subjected to the simple operation of cutting off the extruding portion of the iris and the stump seared by the thermal or galvano-cautery. As a portion of the iris remained and healed in the wound an ectasia of greater or less degree followed this method.

Many reports, not alone of increased tension but of infection of such a cicatrix years after the injury and leading to suppurative irido-choroiditis and panophthalmitis, are reported by Zehender[58], Swanzy[59], Leber[60], and von Arlt[61], so that the healing of the iris

[57]John Dunn. Some Remarks on the Practical Value of the Sphygmomanometer to the Ophthalmologist. *Arch. of Ophth.*, Nov., 1909.

[58]Zehender. Ueber periphere Iris-Vorfälle. *Bericht der Ophth. Gesell.*, 1882, p. 120.

[59]Swanzy. Discussion of Zehender's paper.

[60]Leber. Discussion of Zehender's paper.

[61]von Arlt. Discussion of Zehender's paper.

within a corneal wound or perforation is looked upon with apprehension. Leber explains his operation for loosening and removing old iris prolapse. In many cases, especially in children and when the eye is inflamed and painful general anesthesia is necessary. Even under general anesthesia the eye is fully cocainized. A lid speculum is commonly used from the temporal side. Other operators, including the

Fig. 383.
Smith Hook for Elevation of Lid.

author, in all operations for opening the globe prefer lifting the upper lid by the Fisher lid holder or large strabismus hook as used by Major Smith and D. W. Greene in expression of cataract in the capsule. The globe is held by fixation forceps near the prolapse at the corneo-scleral margin[62].

A conical Anel's sound or Wilder's dilator is held in one hand of the operator and in the other a fine, straight, mouse-tooth iris forceps. The point of the sound is pushed into the exudate at the edge of the prolapse and this under-

Fig. 384.
Wilder's Dilator.

mined throughout the iris proper, (easily done in fresh cases) when the forceps seizes the membrane and removes it. In older cases the separation of the membrane from the iris tissue is more difficult, but it can always be stripped off if a little care be exercised.

The next step is to loosen the iris from the wound. This is also done by the conical sound, which is placed between the prolapse and the sides of the wound canal. If any membrane remains it is removed by forceps. The neck of the prolapse having been freed the conical sound may be bent a little and by its aid the iris pushed back into the anterior chamber, into which the sound may enter 1 to 2 mm. between the prolapse and the anterior surface of the cornea. It can thereby be freed together with all of iris falling

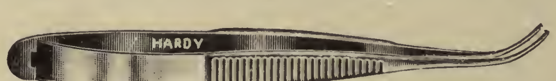

Fig: 385.
Collins' One-half Curved Iris Forceps.

into the anterior chamber; or a fine spatula may be used for the same purpose, taking special care not to scratch the anterior surface of the lens, thereby bruising it and, later, causing traumatic cataract.

The neck of the prolapse is now seized by the forceps, slightly withdrawn and cut away by de Wecker's scissors placed flat against the globe.

The stretched iris then generally recedes by itself into the anterior chamber, the edges being free from the wound canal. If not, a fine curved

[62]See in this System the chapter on Extraction of Cataract (the Smith Operation) in the capsule.

probe or spatula may be inserted and the iris gently stroked away from the dangerous proximity of the opening, care being taken that the sphincter angles are equidistant from the limbus. If the wound canal be very narrow this procedure may have to be made by the conical sound and a very fine probe. If any of the iris tissue is left in the canal it is to be removed by

After cutting the iris tissue close to the cornea, he places a small, horn spatula into the corneal wound, permitting the iris, aided by the myotic action of the eserin, to withdraw into the anterior chamber. After 24 to 48 hours he uses atropin. He adopted this procedure after his observations that mydriatics will not dilate the pupil when there is an open or leaking anterior chamber, while myotics act with an open corneal wound. The wound is then covered with powdered iodoform or xeroform, as well as with a 50 per cent argyrol solution, and 1:3,000 sublimate salve. If the wound coapts well, it is bandaged; otherwise it is necessary to cover the defect by a bridge of conjunctiva, after the manner of Kuhnt (q. v.).

Heckel[63] uses a solution of eserin sulphate 1 gr. to the ounce, before removing a prolapsed iris.

The result of the operation is the removal of the iridic and exudative plug from the corneal wound which comes together and heals firmly, leaving no weak spot for the entrance of germs. A coloboma is made which should appear as if made at the time of the infliction of the wound. The removal of an iris prolapse by such an operation is possible and indicated only in fresh cases when the connection between the iris and corneal tissue is a recent fibrinous exudation and has not yet proceeded to true cicatrization. Cicatricial tissue would prevent loosening of the neck of the prolapse and clearing out of the wound canal.

The iris prolapse is not firmly connected with the walls of the wound by exudate until after the eighth day.

The operation is also mainly indicated in peripheral prolapse. Large central prolapses are not amenable to such treatment since only a small part of the cornea remains and the iris must be removed, to prevent recurrence. These are to be left entirely alone and later to be subjected to a staphyloma operation.

This operation is contra-indicated in suppurative cases, where the entrance of an instrument into the anterior chamber would be apt to carry infection into the interior of the eye. One should wait in such cases until the suppurative process has been subdued.

Da Gama Pinto[64] showed that bottle-and-bubble prolapses always heal with synechiæ, in which the foregoing operation is contra-indicated. In a few cases, especially in children when the loss of corneal substance is large and the perforation of Descemet's membrane is small, atropin or eserin and a bandage may cause the prolapse to disappear. The size and position of the wound, the extent of the prolapse and its duration should be considered in treatment.

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[63]Heckel, E. B.—A New Procedure for Treating a Prolapse of the Iris complicating Perforating Wound of the Cornea. *Penna. Med. Jour.*, Aug., fine forceps and scissors.

[64]Da Gama Pinto. Zur Behandlung des Iris-Vorfalles bei Hornhautgeschwüren. *Klin. Mon. f. Aug.*, 1887, XXV, p. 1.

If the prolapse be fresh and not too large and the wound be radial, its replacement should be attempted; eserin should be instilled and the eye closed. If the wound be crucial, the iris prolapse older and if the wound gape it is best to excise the prolapse.

When the bleeding is considerable a clear view of the injury is greatly hindered and the operator may not be able to decide whether all of the iris is removed from the wound (Franke[65]). When the wound is straight and radial it tends to close and if the iris be freed from it the latter generally withdraws into the anterior chamber.

Peripheral wounds of the cornea whose edges are close and parallel are apt to retain the iris in their posterior lips.

Nicati[66] indents the globe a little, causing the iris to protrude. He then seizes the small protrusion by forceps, snips it with scissors and makes an opening (iridotomy) in it.

In old iris prolapse the operation of election is that for excision of staphyloma. Old, small, bead-like prolapses are best seared by the cautery.

P. Chalmers Jameson[67] advises for *iris prolapse in small circumscribed wounds of the cornea* that a peripheral incision in the cornea should be made from the side opposite to that portion of the iris which is incarcerated, traction being made toward the pupillary border of incarceration. In attempting it from the same side the iris is more likely to be torn if (from agglutination or strangulation) the incarceration is resistant. Traction on the ciliary body can be avoided by delicate manipulation. Gentle pressure on the posterior surface of the cornea would assist in breaking up adhesions. Slight traction should be first made on the broadest portion of the incarceration and on the two angles at the junction of the iris border and wound, before final effort is exerted upon it as a whole. For this purpose he has recourse to a slender, blunt-pointed hook, the shank made of malleable material, the bend like a button or shepherd's crook. The advantage in a hook of this construction is that the free end, bend and neck can all be utilized. Forceps will rarely be necessary. He claims that the method enables one to substitute moderate traction from within the anterior chamber for what must sometimes be damaging pressure to the iris on the outside. It preserves to the greatest degree the edges of the corneal wound from instrumental injury in replacement. It calls into use two efficacious physical forces in replacement, instead of one, namely, slight manipulation from without, and traction from within the anterior chamber. The peripheral incision of the cornea diverts the flow of aqueous from the direction of the corneal wound, thus lessening the danger of secondary prolapse; and the equalization of aqueous pressure on the cornea by pheripheral incision permits the lips of the wound to approximate and coapt more thoroughly, inviting quicker closure—thus furthering the healing process. It permits of more complete and thorough irrigation of the anterior chamber after replacement.

Prolapse of the ciliary body and choroid should be replaced within the scleral capsule and retained by scleral and conjunctival sutures, if these structures are not seriously injured. Otherwise the parts pro-

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[65]Franke. Zur Behandlung des Traumatischen Iris-Vorfalles, *Klin. Mon. f. Aug.*, 1892, XXX, p. 96.

[66]Nicati. De l'excision fenêtrée de l'iris. *Arch. d'ophtal.*, 1883, III, p. 400.

[67]P. Chalmers Jameson. *Arch. of Ophth.*, Vol. XXXVIII, No. 1, 1909.

truding should be snipped off by scissors placed flat to the globe, and the wound toilet completed before suturing.

Foreign Bodies in the Iris.

The removal of foreign bodies from the iris will in most cases be accomplished by iridectomy (q. v.), described elsewhere in this *System*.

Extraction of a foreign body without iridectomy can usually only be made of objects lying loose in the anterior chamber, or of those lightly imbedded in the iris. Foreign bodies in the iris demand prompt removal, for if allowed to remain they speedily set up a severe irritation. Therefore, if the foreign body cannot be removed by the magnet, forceps must be used, in either case through the original wound of entrance or through an operative wound made later, as described in the chapter on that subject.

If the foreign body cannot be readily disentangled from the tissue we may succeed in drawing the portion of the iris containing it through the wound so that we can more readily have access to it, and then replace the iris; but usually an iridectomy involving the iris containing the foreign body must be made.

A blunt hook passed through an operative wound may aid in freeing the foreign body from the iris and angle of the anterior chamber when it is impacted in the root of the iris, after which the magnet or forceps may be used for removal. Adolf Alt[68] notes that sometimes a foreign body, after having struck the iris, will fall into the angle between iris and cornea. Its removal from such a position is very troublesome, especially if it is not iron or steel and very small. In such a case it is well first to move the foreign body with a needle into a position on the iris nearer to the pupillary edge and then to remove it, with a portion of the iris, by iridectomy. For magnetizable bodies in the iris the Hirschberg magnet or small tips on the flexible arm of the Victor magnet find their greatest use.

A magnetized keratome or forceps, as advocated by Edw. Jackson[69], or a magnetized steel spud is also useful, but I prefer the giant magnet used after the manner of Haab for a magnetizable object.

Traumatic Irido-dialysis.

On account of the monocular diplopia produced by the two pupils the bridge may be cut through (iridotomy) by a single sweep of the scissors (after corneal incision) or the bridge may be removed by iridectomy.

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[68]Alt. *A Treatise on Ophthalmology*, 2nd Edition, p. 214.

[69]Edw. Jackson. Scissors-Magnet-Extraction of Iron from Eyeball. *Trans. Sec. on Ophth., A. M. A.*, 1909, p. 30.

Amedie[70] made a corneal section and brought the periphery of the iris into the wound—a risky procedure.

P. Chalmers Jameson[71] has recently presented a new method for operating in iridodialysis, the objects of the operation being as follows: 1. Re-attachment of the torn iris as near to its normal position as possible. 2. Reattachment to a fresh surface within the anterior chamber, without incarceration. 3. Simple, accurate, and practical technique. The first is accomplished by making the necessary incision into the sinus of the anterior chamber well back from the limbus. The second by bringing the torn iris against a linear incision within the anterior chamber—not between its lips. The third, by the introduction of sutures before incision is made into the anterior chamber, and by impinging the iris against the resistant posterior surface of the cornea the iris is neither torn in the effort to perforate it nor lacerated by forceps.

Operations for *occlusion* and *seclusion* of the pupil following accidents are discussed under the headings of Iridectomy and Iridotomy.

Operations for *pupillary membranes* or secondary cataract are discussed under the headings of Cataract.

Operations for *anterior synechiæ* or adherent leucoma, cystoid cicatrices, staphyloma, etc., and posterior synechiæ are also described in Alt's chapter, this *System.*[72]

Injuries to the Lens and their Treatment.

The treatment of *traumatic cataract* is both medical and surgical. In recent cases the first indication after antisepsis of the conjunctival cul-de-sac is *atropin* to dilate the pupil and to paralyze the ciliary muscle. One per cent. atropin solution should be dropped into the eye three or five times a day; or even a 5 per cent. solution may be used at first to insure dilatation of the pupil, care being taken not to poison the patient, for this strong solution saturates the system.

In the case of non-penetrating wounds of the eyeball a bandage should not be applied until full action is obtained; but in wounds reaching the anterior chamber the mydriatic action of atropin is not secured until the wound has closed. Atropin causes increase of intraocular tension and thus the eye should be carefully watched and the tension estimated daily during its use.

Dionin in 5 to 10 per cent. solutions, or the pure powder, is a most effective local analgesic and from its lymphagogic action leads to reabsorption of the cataractous masses in the lens capsule and anterior chamber, and in some authoritative instances is known to have caused clearing of a lenticular opacity. It furnishes an analgesia of from 3 to

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[70]Amedie. *Gaz. des Hôp. de Paris*, 1866; quoted by Czermak, *Augenärztliche Operationen.*

[71]Jameson. Reattachment in Irido-dialysis; a method which does not incarcerate the iris. *Arch. of Oph.*, July, 1909, p. 391.

[72]Many of the instruments mentioned in this chapter are pictured and described in the section contributed by Guilford.

24 hours after each application. For the first few instillations it produces great chemosis of the conjunctiva, and with this speedy resorption of intra-ocular exudates, but this reaction is soon lost, so that after a few applications but little lymphagogic action is observed.

A protective bandage should always be put over the wounded eye, and in large wounds over both, to protect the eye from external infection, from light; also to keep it quiet. 1:3,000 sublimate solution and argyrol are effective antiseptics.

Iced applications immediately after the injury for the first 24 hours, applied over compresses wet with 1:5,000 sublimate solution reduce the immediate swelling of the tissues and the tendency to infection. The artificial leech may be applied to the temple for the same purpose. If iritis or irido-cyclitis arises we endeavor to combat this by hot compresses and mercurial subconjunctival injections (q. v.). If tension increases operative treatment must not be delayed beyond 24 hours.

Paracentesis of the anterior chamber may then be made, preferably by a fine von Graefe knife if there be no lens masses in the anterior chamber. If, however, the anterior chamber becomes filled and the intraocular tension rises linear extraction is indicated up to the age of 35 to 40, after which the regular flap extraction is preferable.

Operative Discission.

The danger of vitreous prolapse must ever be borne in mind on account of the rupture of the suspensory ligament that usually accompanies traumatic cataract. This is a complication not always easy to recognize, especially in cataract from contusion. Since the vitreous inevitably forces itself into the corneal incision if the ordinary form of extraction be attempted, a cataract of this nature should, if possible, be dealt with by discission with two needles without making any corneal cut. The discission wound should be small, to prevent escape of a large quantity of lens substance into the anterior chamber and so set up glaucoma. The operation may have to be repeated in two weeks to two months and perhaps several may be necessary. Although this method is slow, it is safe and sound. (See the chapter on Discission of Juvenile Cataract, by Callan.)

In persons above 45 years of age and with *traumatic cataract,* the regular, 3/5 corneal circumference flap extraction with a conjunctival flap (q. v.) is indicated, and where there is evidence of rupture of the zonula the Kuhnt bipedunculated flap should be made after an incision of 3/5 of the clear cornea at the upper limbus, for at this age and after the nucleus is hard and large, it will freely come out of the capsule, so that the operation is practically the ordinary form of extraction.

As a rule iridectomy should not be made in traumatic cataract un-

less the iris threatens to prolapse as there has already been sufficient damage to the tissues from the original injury.

These methods require great care not to rupture the zonula or posterior capsule and thus allow escape of vitreous into the wound.

Colin Campbell[73] gives the following as a procedure that may save the patient from prolonged irido-cyclitis or thickened secondary membranes after cataract extraction with iridectomy when we are so unfortunate as to leave the capsule in the wound.

The wound is opened a few days later to introduce Lang's knife needle from the opposite periphery of the cornea and sweep around so as to divide the adhesion. A Saunders' needle (q. v.) with blunted point (after using a sharp Saunders' to make the puncture) does not possess the objectionable shoulder and conical shaft of Lang's model, and may be used in preference.

In the cataract of sympathetic ophthalmia no operation should be attempted on the sympathizing eye until all acute symptoms have subsided for several months, for any attempt to perform an iridectomy, to open the pupil, to extract or divide a cataract, or even to do a paracentesis of the cornea or a sclerotomy (even if successful at the time of operation) will be followed by accentuation of the symptoms and increased inflammatory exudation with reclosure of the pupil.

After a sufficient time— a year or eighteen months—has elapsed, and if, during that interval, there has been no recurrence of inflammation, the intraocular tension has not diminished, and the patient's perception of light be satisfactory, operative interference may be considered. This category includes cases in which the sympathizing eye has become quiet, with almost complete posterior synechia, pupil occluded, where vision equals perception of light, projection good, tension normal or slightly below normal, the exciting eye not a factor; cases in which cataract has formed in the sympathizing eye as a result of sympathetic inflammation; cases of posterior synechiæ, eye quiet, projection good, the exciting eye not a factor; cases in which, with occluded pupil, total posterior synechiæ exists in the sympathizing eye. Finally, it is not contraindicated even when the tension is plus and increasing (secondary glaucoma) projection still good; the inflammatory process in a subacute stage, the exciting eye not now a factor.

Should operation be resolved on the iris should as far as possible be let alone. The lens must be got rid of, either by needling in the manner suggested by Critchett, or, in more favorable cases, by extraction with a curette after the toughened capsule has been divided with a knife. Once the cataract has been removed an iridotomy may open up the pupil sufficiently to allow light to enter the eye, and enable the

[73]Campbell. Personal Communication, 1910.

patient to see as well as the damaged state of the retina will permit. In operating on such eyes it must be remembered that the vitreous is quite fluid and escapes readily, therefore it is important that all incisions be as small as possible and made wholly in the cornea. After operation the eye must be carefully bandaged and the patient kept (in a dark room) quiet in bed; while local application of ice and the administration of sedatives internally will do much to prevent the occurrence of inflammatory reaction.

In operating on sympathetic soft cataract Hirschberg[74] does an operation which consists of section at the lower limbus. Carefully avoiding the iris, he removes the capsule with a four-toothed forceps. The pupil at once enlarges and lens matter oozes, which is removed partly by irrigation, partly by external pressure.

In another case Hirschberg cut the capsule with Knapp's knife. This had to be repeated, as the lens matter was not sufficiently removed by the first operation. If in such cases the pupil should close Hirschberg advocates opening it with Knapp's knife. He considers this preferable to the method of *Wenzel*, in which the cataract knife penetrates cornea, iris and lens.

Borghetti[75] makes a sclero-corneal incision with a Graefe knife on each side, leaving a bridge of cornea above and below. The iris is cut all along this incision close to its base, leaving a bit of it at the top and bottom. The lens is now needled or its elements disintegrated by pressure. The next day the capsule is removed and the lens is extracted by suction.

FOREIGN BODIES IN THE CRYSTALLINE LENS.

If a copper, stone, or other non-magnetic foreign body becomes imbedded and is well tolerated, it may be allowed to remain until the lens has become opaque, when it should be removed together with the cataract. But if the foreign body is of iron or steel it is better to extract it as soon as possible by the magnet and to extract the cataract later.

If the steel splinter be loosely impacted in the lens capsule a peripheral corneal incision and the tip of the Hirschberg or extended Victor magnet may be introduced into the anterior chamber, upon withdrawal of which the chip will adhere and be removed; or the Haab magnet may be used. If the wound of entrance be large, it may be further enlarged, although where Nature has already closed the wound, it is preferable to make a new, clean incision, as this may usually be made nearer the foreign body than the wound of entrance.

The magnetized lance may also be used with "safety, exactitude and elegance."

If the foreign body be more deeply impacted the large Haab or the Victor magnet may be used and the foreign body withdrawn with less danger of further rupture of the lenticular capsule.

If the lens be greatly swollen it may be removed (as previously described) at the same time, but as a rule the cataract is to be dealt

[74] Hirschberg. *Centralbl. f. Aug.*, 1905, p. 97.
[75] Borghetti. *Annali di Ottalmologia*, April, 1908.

with later. For a full description of all these magnet operations consult Thomson's chapter.

Dislocations of the lens amenable to operation are also described elsewhere.

REMOVAL OF FOREIGN BODIES FROM THE POSTERIOR SEGMENT OF THE EYEBALL.

Operations following injuries involving the vitreous are mostly confined to abscissions of vitreous prolapse by cuting it off with scissors, the blades being placed flat on the surface of the globe, after which the wound is closed by scleral and conjunctival sutures. Injections of salt solution and of calf's vitreous (to replace the lost substance) are dealt with in the chapter on Detachment of the Retina.

The removal of foreign bodies from the posterior chamber of the eye gives the principal indication for operation within the vitreous.

A large proportion of the cases brought to the ophthalmologist are of traumatic nature and in manufacturing communities injuries attended by entrance of foreign bodies are extremely common. Simeon Snell[76] says that very few persons working at the iron and steel trades escape injury in the course of two years, and there are many more accidents to the eye in the course of this time than the number of men employed. Clinically, we may divide these cases into non-penetrating injuries, with or without impaction of foreign bodies, and these are mostly due to scale, emery or iron splinters in the cornea; and foreign bodies which penetrate the eyeball. The large majority of the latter are retained within the ball, but some may pass through both sides and become impacted within the orbit, or in the case of bullet wounds pass entirely through. All these injuries may be infected or non-infected.

Foreign bodies that can be removed from the eye may be classed in two groups: First, various forms of iron splinters, which inflict about 75 per cent. of all injuries or cuts that penetrate the globe; the balance of copper, stone, wood and glass particles, which, as a rule, enter the eye more rarely and remain lodged in the anterior portion most frequently. Copper particles, however, may go with exceeding force, as after explosions and from firearms.

An eye in which a piece of iron, steel, or copper is buried invariably deteriorates, and ultimately becomes blind *(siderosis bulbi)* if the foreign body is not removed, or unless it becomes completely encapsulated. In many cases this degeneration is preceded by the symptoms of hemeralopia.

We may also anatomically, and with respect to prognosis, differ-

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[76] **Snell.** ***On the Prevention of Eye Accidents in Trades*****, London, 1899.**

entiate these penetrating bodies into two classes, one in the anterior and one in the posterior segment.

It is universally recognized that when the foreign body is in the anterior segment of the eye, the injury is much less serious than when it has passed on through the lens into the posterior segment or has entered the vitreous chamber through the ciliary region or the sclera beyond.

The *time intervening between the accident and the operation for the removal* is an important factor, the best results being obtained in those cases which are operated on within the first 24 hours following the accident. Any foreign body imbedded in the eye soon becomes surrounded by a plastic exudate which, though quite soft, appears to hold it firmly and offers great resistance to its removal. When the piece of metal or other foreign body has been in the eye some days or weeks, the force required to withdraw it drags so much of the neighboring tissues that the subsequent inflammatory reaction, together with that resulting from the original trauma, reduces the possibility of a satisfactory result and undoubtedly, in some cases, brings on a marked iridocyclitis, with early shrinkage of the globe.

The *situation of the wound of entry* is of considerable interest and importance. In corneal wounds the ultimate result depends on the final position of the metal—when in the lens the results are excellent; when the metal has passed through the lens into the vitreous or is imbedded in the coats of the eye beyond, the results are disastrous.

Wharton[78] states that in wounds of the ciliary body or further back in the sclera, the results are not usually good and enucleation may be necessary. The danger of sympathetic ophthalmitis is ever present in eyes retained after such accidents, even though the foreign body be successfully removed. Perhaps surgeons are nowadays too conservative in such accidents and some eyes are kept in that might better have been immediately enucleated. Such patients should be kept under observation for several years after apparent recovery.

Concerning the septicity of the wound, all chips of metal entering an eye may be considered as free from organisms, the septic inflammations being produced by the subsequent entry of organisms either through the tract of the wound or during the operation for removal.

E. E. Maddox writes the author as follows:

"*Paralenticular Route to the Vitreous.* A small boy was struck in the eye by a fragment of a copper percussion cap. At the time when I first saw him, about three months after, no aperture of entrance was visible. The eyeball was inflamed; the iris was discolored brown, and the pupil dimmed with iritis exudation. Enucleation had been advised by an eminent colleague. After subduing the inflammation by powerful antiphlogistic meas-

[78]Wharton. The Giant Magnet. *Ophth. Review*, Dec., 1905, p. 345.

ures—mercury, electric heat, atropin, dionin, etc., the pupil dilated and the iritis almost disappeared in a week or ten days. A white mass could now be seen through the pupil lying on the ora serrata. The encapsulation of the copper explained why the iritis could be dispelled. Under chloroform I made an iridectomy downwards, the corneal incision being made with a narrow linear knife, coming out perpendicular to the surface, slightly within the limbus. A fine pair of forceps with spoon-shaped ends and bent shanks, which enabled me to watch their progress, was then pushed gently through the suspensory ligament of the lens and the foreign body grasped and removed. The eye healed perfectly, no cataract ensued, and it became a strong and useful eye. The absence of any hemorrhage that might obscure the proceeding, and the visibility of all that is done, are great points in favor of this route."

The Removal of Non-Magnetizable Foreign Bodies from the Interior of the Eye.

Non-magnetizable foreign bodies in the interior of the eye, such as particles of copper, glass, stone, etc., are very difficult to remove, but fortunately injuries with such particles do not occur nearly as frequently nor is their prolonged sojourn in the eye nearly as apt to damage it as iron or steel. With regard to such particles (not of iron or steel) Haab[79] says it is often more advisable to leave them in the eye (unless, of course, they can be seen and are accessible), than to open up the vitreous and probe around, as it were, in the dark, with forceps and other instruments in search of the foreign body. To endeavor to remove such bodies oftentimes damages the eye more than to leave them undisturbed.

Fragments of *stone, wood and glass* enter the eye more rarely and remain lodged in the front portion of the eye more often than is the case with iron. *Copper and brass splinters* are as a rule projected with much more force, but since the days of the percussion cap are over they are less frequently met with. We occasionally see copper splinters which enter the eye in the case of brass workers and copper miners, and from the effect of explosions of powder, and dynamite caps and shells.

The *diagnosis* is obtained by a history of the accident, the ophthalmoscope, diaphanoscope, focal illuminator and the X-ray. In recent cases ophthalmoscopy may show a red or yellowish foreign body, or in older ones cyclitis or irido-cyclitis. Before or after an operation for removal, a considerable brownish-red opacity of the vitreous and iris may be seen, as well as very fine deposits on the lens capsule.

Prognosis. In my experience these instances have been invariably fatal to the preservation of vision and the eye in most cases has come to enucleation.

Caspar[80] says injuries of the deeper portions of the eye by copper

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[79]Haab. The Removal of Foreign Bodies from the Eye. *Trans. Sec. on Ophth. A. M. A.*, 1902, p. 85.

[80]Caspar. Beitrag zur Kenntnis der Verletzungen des Auges durch Kupfersplitter. *Klin. Monat. f. Aug.*, XLVI, II 1908, p. 179.

are of evil prognosis. Leber[81] showed that copper is very apt to arouse suppuration in the vascular parts of the eye even without introduction of bacteria. On the other hand, copper imbedded in the avascular parts, e. g., the lens, may be well borne. Especially unfavorable are those cases in which the foreign body penetrates into the vitreous, as its extraction may be difficult or impossible.

Morrison[82] says notwithstanding the well-known tendency of copper to produce suppuration, one case of this sort recovered after having harbored a piece of copper for a whole year.

Weiss[83] says that the prognosis of copper injuries involving the anterior segment of the eye is not unfavorable, provided the metal contains no virulent germs and is removed early; that neither a mydriatic nor a miotic should be used, lest the position of the foreign body shift and be lost to view in the anterior chamber. For the same reason attempts at extraction without an anesthetic is dangerous.

Particles of glass, stone, and coal penetrating the eye and remaining in the vitreous when aseptic and in a position difficult of removal, may be allowed to remain in the hope that they may be retained without further damage, as they do not cause chemical changes like iron and copper. The exception to this rule is a wound in the ciliary region, causing fear of sympathetic ophthalmia.

Grains of *lead* are practically only found from shot-gun injuries.

If it be decided to attempt removal of a foreign body from the interior of the eye it may be done through the original wound if the foreign body be found within its vicinity. After localization the Desmarres capsule forceps should be introduced, the object seized if possible, and withdrawn; followed by antiseptic treatment and bandage. It is exceedingly difficult to grasp such splinters.

If the foreign body is within the anterior chamber it may be advisable to make an incision, and here a blunt hook may be useful in engaging the intruder, and with the help of the forceps in the other hand the same may be seized and removed.

Few cases of non-magnetizable foreign bodies within the vitreous cavity have been successfully treated by removal of the foreign body with preservation of sight, especially if it has been within the eye for any length of time, as the exudation ties the tissues so that great trauma is produced in the attempted removal. As a rule enucleation subsequently has to be made.

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[81]Leber. Die Enstehung der Entzündung und die Wirkung der entzündungserregenden Schädlichkeiten, Leipzig, 1891.

[82]Morrison. *Indiana Med. Jour.*, XXVI, No. 3.

[83]Weiss. *Die Ophth. Klinik*, May 5, 1908.

INJURIES TO THE RETINA AND THEIR CONDUCT.

Wounds of the retina are complications of injuries involving the external coats of the globe and need no direct treatment. Foreign bodies in the retina are discussed under Magnet Operations. Detachment of the retina is dealt with in its proper chapter.

WOUNDS OF THE OPTIC NERVE.

Injuries to the optic nerve are not properly subject to surgical operation. They are generally complications of foreign bodies in and injuries to the walls of the orbit and are dealt with under special chapters (q. v.).

INJURIES TO THE LIDS.

Longitudinal wounds of the lids which do not gape tend to

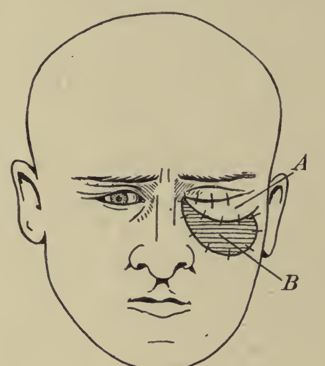

Fig. 386.

Method of Sliding Flap and Wolfe Graft Transplantation for Restoration of the Lower Lid. Large Wolfe Graft Transplanted from arm (*B*), sliding flaps from cheek (*A*) and Thiersch grafts to line of orbit.

heal kindly, unless they are deep or over one centimeter in length, require no stitches; but if the deeper structures are injured, especially if the levator tendon be cut across so that ptosis is produced, the divided ends should be sought for and joined together with several interrupted catgut sutures, and the skin wound then sewed with silk.

When the lid is divided *vertically* so that a coloboma is produced the edges should be brought together, not only by fine silk sutures, but, as the skin is delicate and easily torn if swelling results from the trauma, deep tension sutures should also be placed outside of the wound sutures. In old cases the edges of the coloboma are to be freshened and then sutured together. Where sloughing has caused loss of tissue, sliding or pedunculated flaps taken from the forehead or temple in the case of the upper lid (see Beard's chapter), or from the neck according

to Snydacker[84], or from the arm (according to the Italian method), or whole skin grafts made after the manner of Wolfe, taken from the arm or mastoid, as used by the author; or, when the skin only is affect-

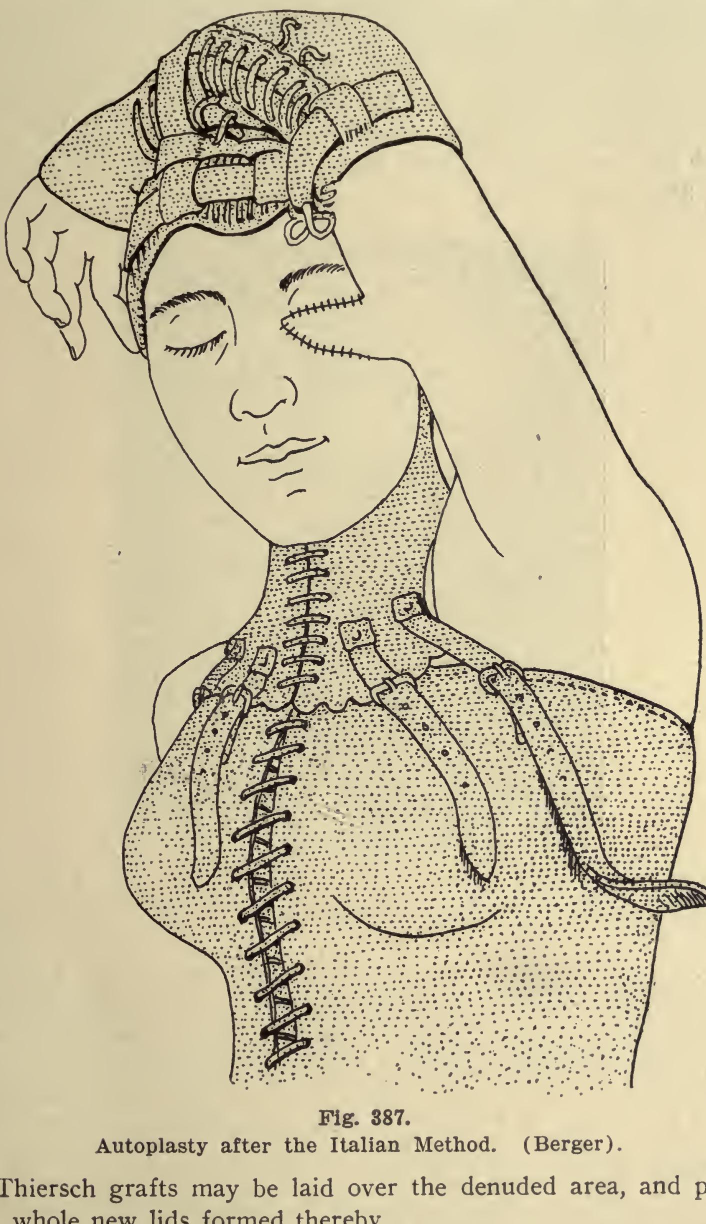

Fig. 387.
Autoplasty after the Italian Method. (Berger).

ed, Thiersch grafts may be laid over the denuded area, and part or even whole new lids formed thereby.

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[84]Snydacker. A Plastic Operation on the eyelids by means of skin Flaps Taken from the Neck. *Arch. of Ophth.*, Jan., 1906, p. 57.

Haab[85], Pfalz[86], Uhlbrich[87], and others, as well as the author's experience show that Thiersch and whole skin-grafts are supplanting most forms of flap operations.

Foreign Bodies in and Burns of the Lids.

With the exception of powder and sand grains impacted in the lids from explosions, other foreign bodies are rarely seen, as these structures are thin and objects projected with much force usually pass through into the eye or orbit. The treatment of thermal injuries is dealt with on general surgical principles.

Fig. 388.

Results of operation for Restoration of the Orbit. Author's Case. Large Wolfe graft transplanted from arm, sliding flaps from cheek and Thiersch grafts to line orbit.

Heustis[88] gives a satisfactory method of removing powder stains in fresh cases. The patient must first be thoroughly anesthetized. Then with a stiff nail-brush, and using soap and water rendered antiseptic by carbolic acid, bichloride solution, or any other antiseptic that may please the operator, scrub the part thoroughly. Do not hesitate to draw blood, and do not cease until the grains of powder have been entirely removed. Should it become necessary to remove the entire cuticle do not fail to do so, as it will reform in a few days. It is sometimes impossible to eradicate a spot entirely,

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[85]Haab. *Atlas of Ophth. Operations*, 1908.

[86]Pfalz. Uber Behandlung und Nachbehundlung von Verletzungen und Verbrennungen an den Augen. *Zeitscher. f. Augenheilk.*, XXII, p. 492, 1909; and *Deut. Med. Woch.*, No. 19, p. 823, 1908.

[87]Uhlbrich. *Arch. f. Augenheilk.*, LVIII, p. 9.

[88]Heustis. A Satisfactory Method of Removing Powder Stains in Fresh Cases. *Ophthal. Record*, Oct., 1898, p. 505.

and in this case a smooth, elliptical incision is to be made, the stain removed, and a light suture inserted. Following the operation of scrubbing, it is only necessary to cut a covering the shape of the surface denuded, soak it in carbolized oil and apply. The next day the patient is liable to complain of a stiffness of the skin of the affected parts, which passes away in a short time. After the skin has resumed its normal condition it may be necessary, where blue spots remain, to remove them by the elliptical incision previously mentioned.

The *therapy of ordinary burns of the lids* is based on general surgical principles. Burns of this character are usually of the first degree, i. e., superficial, involving only the epidermis; when the vitality of the skin has been destroyed, and the true skin or corium cooked by the heat, the burn is then that of the second degree. Application of carron oil,

Fig. 389.

Severe burn of face and scalp, with loss of left eye, treated by Thiersch skin grafting. Author's case.

a mixture of linseed oil and lime water, picric acid ½ per cent. or boric acid ointment 5 per cent. is the chief treatment.

As regards *powder burns of the eye-balls* they are to be treated on general surgical principles.

Burns from Acids and Alkalies.

The *treatment of burns and cauterizations from acids and alkalines* is, first, the use of large quantities of water to wash away the excess of acid, neutralization of the remainder by instillation of alkaline solutions, bicarbonate of soda or potash, lime water or milk in the case of

acids; and 5 per cent diluted acetic acid in the case of alkalies. Ice compress should be applied, followed by hot compress after 24 hours, a bland ointment, such as 5 per cent. iodoform in vaseline, or equal parts of linseed oil and lime water. Dionin in 5 per cent. solution, at first for the pain and, later, in powdered form, assist in the absorption of scar tissue. For this the thiocyanates may likewise be used in 10 to 20 per cent. ointment, or given internally in 0.02 doses three times a day. Atropin in 1 to 2 per cent. solutions keeps the pupil open and prevents iritis.

Lime burns of the eye, particularly of the cornea, are of the utmost importance as regards immediate therapy, which consists in extensive douching with water, picking and wiping out of the lime, and, then, the use of 2 per cent. ammonium chloride solution, which forms a soluble salt of lime and prevents the deposit of calcium compounds in the tissues. Holocain, dionin, and atropin are also indicated. The iodoform salve, and therapy as in the case of acids and alkalies, should likewise be used.

INJURIES TO THE LACHRYMAL APPARATUS AND THEIR TREATMENT.

Dislocation of the lachrymal gland is usually accompanied by injury of the soft parts of the orbit and with external wounds of the lids and eye-brow; in many cases complicated by foreign bodies. In addition to surgical care of the wound and removal of foreign bodies enucleation of the prolapsed gland (q. v.) should be done as recommended by Santucci[89] and Edw. Jackson[90], the latter calling attention to the advisability of X-ray examination for foreign bodies in these cases.

In fresh cases, without external wound, manipulation, followed by a compress bandage, may restore and keep the gland in place, as in an instance reported by Crowder.[91]

Fracture of the walls of the orbit, especially of the nasal process and lachrymal bones, and frontal bones, may be attended by penetration and *laceration of the soft parts of the lachrymal passages* and be followed by atresia of the canals from cicatrization. Removal of spicules of bone and elevation of fragments, together with closure of the external wounds and suturing the injured tissues to a temporary lachrymal style (until healing takes place) may keep the passage permanent.

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[89]Santucci. Der traumatische Vorfall der Thränendrüse und die Zweckmässigkeit ihrer Extirpation. *Centrabl. f. pkt.*, 1904, Aug., p. 345.

[90]Jackson. Traumatic Dislocation of the Lacrimal Gland with Foreign Body in the Orbit. *Opth. Record*, Aug., 1904, p. 345.

[91]Crowder. Dislocation of the Lacrimal Gland. *Opth. Record*, Sept., 1906, p. 422.

Secondary operations for occlusion of the lachrymal passages (q. v.) may have to be made but are never satisfactory on account either of impermeability or defective drainage.

Foreign bodies in the canaliculi should always be sought for and, if present, removed in cases of chronic angular irritation. Hairs, finger-nail clippings, etc., are to be removed by small forceps under proper illumination and magnification.

INJURIES TO THE OCULAR MUSCLES.

The *treatment* of wounds of the ocular muscles, aside from asepsis, is practically that of the advancement operation for strabismus (q. v.). The ends of the divided muscle should be brought together by two or three interrupted sutures, or, if the tendon has been divided, the Worth or other advancement operation may be made. Considerable dissection may have to be done when the injury has happened some time before.

It is worthy of remark that a partial division of the tendon or muscle may not produce permanent disturbance of motility, for it heals rapidly. In some cases it may be necessary to perform a graduated tenotomy of the antagonist to secure muscle equilibrium.

INJURIES TO THE WALLS OF THE ORBIT.

Wounds of the *soft parts* within the orbit are usually complicated with those of the lids, except in impacted fracture. Under antiseptic surgical conditions a drain may be laid and the external wound sutured, when, if healing by first intention has set in, the drain may be removed after 24 hours, and the parts allowed to heal together. If a piece of skin has been completely torn or excised from the brows or lids a Thiersch graft may be applied. The wound should always be carefully probed to determine the extent of a possible foreign body and the X-ray examination should not be neglected.

If the supraorbital fascia be opened catgut stitches may be put in, otherwise the wound should be fully sutured.

Foreign Bodies. Small metallic objects, as shot pellets, bullets, chips of iron, copper, stone, etc., may be left alone to become encapsulated. However, bullets have been successfully removed from the orbit with conservation of the globe, as reported by Posey.[92]

Some foreign bodies may produce orbital phlegmon and inflammation of the optic nerve followed by blindness, so that operation for their removal should be instituted before severe inflamamtion with

[92]Posey. Gunshot Wound of Orbit; Post-traumatic Delirium; Removal of Bullet with Conservation of Globe. *Opth. Record*, March, 1905, p. 112.

great swelling renders it more difficult and dangerous. In fresh cases, after localization by the X-ray, the opening should be carefully probed and enlarged in the direction of entrance; in older cases the sinus followed up or the cicatrix cut open, the foreign body seized by forceps, cut away from the surrounding connective tissue by scissors, carefully dissected out and withdrawn in the direction of least resistance.

One should be sure that all of the foreign body is removed, particularly in the case of wounds, as urged by Edw. Jackson.[93] A drain should be laid in the depths of the wound and gradually withdrawn as healing progresses. In withdrawal of the foreign body and replacing the wound care should be taken not to injure more than is necessary the levator of the lids, the orbicularis, the tear passages, the ocular muscles, and the globe. When the parts have been divided by the injury or by operation they should be carefully sutured in order to regain and preserve their function. If the body has passed through into the spheno-palatine fossa resection of the outer wall of the orbit (Krœnlein's operation q. v.), should be selected as advised by W. Zimmerman.[94]

If the body enter the facial sinuses appropriate operations upon them may be selected. In many cases it is necessary to enucleate the eye-ball, as it is usually ruined, since the retention of a large and usually septic foreign body in the orbit is dangerous to life.

In exophthalmus from *orbital hemorrhage* a pressure bandage and the ice bag are indicated. As a rule it is not advisable to make incisions and withdraw blood unless the high degree of protrusion gives rise to fear for the safety of the cornea.

In cases of *supraorbital neuralgia following injury*, Dowling[95] operates as follows: Under ether anesthesia an incision one inch in length parallel to and below the eye-brow is made. The region of the supraorbital foramen is investigated for signs of previous fractures and, if found, the foramen is converted into a pouch by chiseling and ½ inch of the nerve is resected.

The surgical treatment of fracture of the orbital walls consists in reposition of the injured parts, removal of loose fragments, and rest. This subject is, from another standpoint, treated by the Editor in his chapter on Orbital Operations.

In splintering and fracture of the bones accompanying external wounds in complicated fractures, the loose fragments should be

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[93]Jackson. Traumatic Dislocations of the Lacrimal Gland, with Foreign Body in the Orbit. *Opth. Record*, Aug., 1904, p. 345.

[94]Zimmerman. Schussverletzung der Orbita, Entfernung der Kugel mit Erhaltung des Sehvermögens durch Krönleinsche Operation. *Klin. Mon. f. Aug.*, XLV, Aug.-Sep., 1907, p. 195.

[95]Dowling. Supra-Orbital Neuralgia, etc. *Ophthalmology*, July, 1910, p. 633.

removed by forceps. Those that remain attached by a good-sized band of periosteum which can be replaced and held in position, will heal if put in place. Fragments that may have pierced the soft tissues should be elevated, cleared from the tissues, properly replaced, and held by periosteal catgut sutures, metal clamps, or even by sutures placed in the soft tissues; then a bandage.

Fractures without solution of continuity of the external skin or mucous lining of the walls of the sinuses or the dura mater of the cerebral cavity are generally simple fractures. The complicated fractures, which open up the sinuses, need no direct form of surgical interference. They are generally upwards and inwards, or inwards and downwards, and lead to infective processes from tearing of the mucous membrane lining the pneumatic sinus. Displaced bones forming the inner-upper walls cannot be replaced except by external incision, which may be made below the eye-brow and the bones reposited by periosteal probes and forceps.

The bones of the inner wall and of the nasal processes may be replaced by manipulation (through the nasal pasages) with the flat nasal probe and held in place by nasal tampons. The treatment is usually combined with that of fracture of the nasal bones.

Fracture of the zygoma may extend into, and a piece of bone penetrate the maxillary antrum. This dislocation may be replaced by a forefinger of one hand in the patient's mouth, well behind the zygoma, and the splinter raised into place, the head being steadied by the operator's other hand. If this is not possible a strong resection-hook is passed around the zygoma at the nasal process and by it the bone is pushed into place. If the fracture be complicated by an open wound then the splintered bone may be reached through the opening and raised by forceps.

In complicated, or old healed, fracture of this character, when the deformity is the only defect, it may be well to leave the matter alone as no evil results have been reported from such conditions.

In old, healed fractures of the *orbital rim,* as well as in uncomplicated features, an external incision may be made, with resection of the bone, i. e., an osteotomy, to reach the injured part, free from the impaction and replace it.

Direct fractures of the orbital rim are the rule. Indirect fractures, without misplacement of the fragments, require no operative interference. They are accompanied by indirect fracture of the orbital wall and usually with fracture of the base of the skull.

Direct fractures of the orbital walls are as a rule due to penetrating injuries of the orbit. They are isolated, and are more amenable to surgical intervention than the indirect forms. Under rigid

antiseptic precautions one should freely open the wound of entrance, remove foreign bodies, bone splinters and secretion. Probing and irrigation are not to be done, as pathologic (infective) products may be carried deeper into the tissues. This rule is also to be remembered in dealing with orbital abcesses. Drainage through the opening will remove the secretions and lessen the danger.

The operation for *fracture of the roof of the orbit* will best be conducted by an incision through the brow, with the skin well retracted and, if necessary, resection of the margin of the orbit, to reach safely the foreign body and remove it together with any bone splinters. The finger makes the best probe for the purpose of making the diagnosis; the splinters are seized and removed by forceps.

When the roof of the orbit is known to be fractured, a foreign body impacted therein and the eye-ball destroyed, enucleation of the globe or a partial exenteration of the orbit may be done. In this way direct access is given to the fracture, the foreign body and bone splinters are brought into view and easily removed, and the wound secretion better drained.

All splinters should be taken away, as even very small ones may cause meningitis, brain abscess, and loss of life. If a localized brain abscess common in bullet fractures is found, it should be opened and drained.

In the lighter cases, when brain symptoms do not occur, the eyeball may be retained and simple drainage of the wound secured; but when the bulb is injured there should be no compunction about an enucleation since we thus secure a satisfactory diagnosis and are better able to drain the depths of the wound.

PART V.

CHAPTER I.

SOME OPERATIONS ON THE ORBITAL WALLS AND CONTENTS.

By CASEY A. WOOD, M. D., Chicago, Ill.

Surgical Anatomy of the Orbital Cavities and their Boundaries—Structure of the Orbital Walls and their Relations to the Neighboring Cavities—The Orbital Axes—The Contents of the Orbit—Anesthetics in Orbital Surgery — Exploratory Puncture — Incisions — Orbital Abscess — Orbital Periostitis—Extirpation of Orbital Tumors—Large Tumors Outside the Muscular Cone—Malignant Neoplasms of the Orbit—The Operative Treatment of Orbital Tumors—Operations for the Removal of Tumors of the Optic Nerve—Complications of the Operation—The Methods of Lagrange and Knapp—Exenteration of the Orbit—Partial Evisceration—Complete Evisceration—Post-operative Treatment of Orbital Exenteration—Skin and Mucous Membrane Grafts—Prothesis after Exenteration of the Orbit—Golovine's Operation—Streatfeild and Green's Methods—Orbito-Sinus Exenteration—Extirpation of Cysts of the Orbit—Orbital Angioma and its Treatment—Operations for Pulsating Exophthalmus—Ligature of the Carotid—Ligature of an Ophthalmic Vein—Encephalocele and its Surgical Treatment—Operations on the Orbital Walls—Caries and Necrosis of the Orbital Margins or Walls—Mosetig's Method for Preventing Deformity after Orbital Operations—Resection of the Orbital Margins and Walls—Removal of Bony Tumors from the Orbit—Extirpation of Exostoses and Osteomata—Krönlein's Operation and its Modifications—Czermak's Operation—Operation of Angelucci—Operations for the Relief of Orbital and Intraocular Parasites—Echinococcus — Cysticercus — Filaria Loa.

Surgical Anatomy of the Orbital Cavities and their Boundaries.

More or less symmetrically placed on both sides of the nose, just beneath the frontal bones, are the *two orbits*. Their relations to the neighboring sinuses and to the cranial contents are not less important to the ophthalmologist than to the rhinologist and general surgeon. For this reason a study of the anatomical and physiological peculiarities both of their walls and contents must precede any rational attempt to perform operations upon or about them. In addition, the ophthalmic surgeon must have a practical acquaintance with the rela-

tive depth and other measurements of these spaces both in health and disease and should bear in mind the surgical landmarks that are of most assistance in mapping out the important structures that lie within and about each orbit. He should not undertake deep operations in their locality until he has examined many bony specimens and made numerous dissections of the face and head. In this way he will familiarize himself with the locality and appearance of the soft and osseous structures that may be involved in his surgical interventions.

Diagrams and descriptions have an unquestionable value in this regard but *careful exploration of the parts in situ* is required as an introduction to successful surgery of the orbit.

Structure of the Orbital Walls and their Relations to the Neighboring Cavities.

The *apex of the orbit* in Caucasians is directed forwards and inwards in such fashion that the inner walls of the two cavities are almost parallel, while their outer walls form with one another an angle of almost 90 degrees. *The average depth, intra vitam, of the orbit* is about 5 cm., that is to say, nearly two inches—a fact extremely important to remember, especially in operations on or about this cavity.

The *upper margin of the orbit* is formed by the frontal bone, the outer and about half the lower margin by the orbital and facial surface of the malar bone. The internal border and the lower margin are made up by the outer surfaces of the frontal process of the superior maxillary.

The outline of the margin of each orbit exhibits *three sutures;* below, the *malo-maxillary;* internally, the *fronto-malar* and externally, the *fronto-maxillary.*

At the apex of this space are seen two openings, the *sphenoidal fissure* and the *optic foramen.* Through the former, which is by far the larger of the two, pass the ophthalmic veins, the third and fourth division of the fifth and the sixth nerves. The *foramen opticum* gives passage to the optic nerve and the ophthalmic artery.

According to Cunningham[1], the *roof of the orbit* is formed in front by the orbital plate of the frontal bone and behind by a small triangular piece of the lesser wing of the sphenoid. The latter surrounds the optic foramen and forms the upper border of the sphenoidal fissure. Externally this surface is separated from the outer wall by the sphenoidal fissure posteriorly; anteriorly by an irregular suture between the orbital part of the frontal and the upper margin of the orbital surface of the great wing of the sphenoid, external to which the external angular process of the frontal bone articulates with the malar. Internally the roof is separated from the inner wall by a suture, more or less horizontal in direction, between the orbital plate of the frontal and the following bones (in order from before backwards), the frontal process of the superior maxilla, the lachrymal bone, and the *os planum* of the ethmoid. In the sutures between the ethmoid and the frontal bone there are two foramina, the anterior and posterior internal orbital or ethmoidal canals. Both these canals transmit ethmoidal vessels—the anterior giving passage to the nasal nerve as well. The roof is concave from side to side, and to some extent also from before backwards.

Within the margin of the orbit, about midway between the fronto-maxillary suture and the supra-orbital notch or foramen, is seen a small depression, occasionally replaced by a spine, for the attachment of the pulley of the superior oblique muscle. Beneath the external angular process

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[1]Cunningham. *Text Book of Anatomy*, p. 145-47. The purely anatomical descriptions given here of the orbital relations are largely quoted from this admirable manual.

the roof is more deeply excavated, forming a shallow fossa for the lodgment of the lachrymal gland. In front, the roof separates the orbit from the frontal sinus, and along its inner border it is in relation with the ethmoid cells. The relation to these air spaces varies, depending on the development and size of the sinuses. The remainder of the orbital roof, which is quite thin, forms by its upper surface the floor of the anterior cranial fossa, on which lie the frontal lobes of the brain.

The *floor of the orbit* is formed by the orbital plate of the superior maxilla, together with part of the orbital surface of the malar bone, and, posteriorly, a small triangular piece of bone, the orbital process of the palate. Ex-

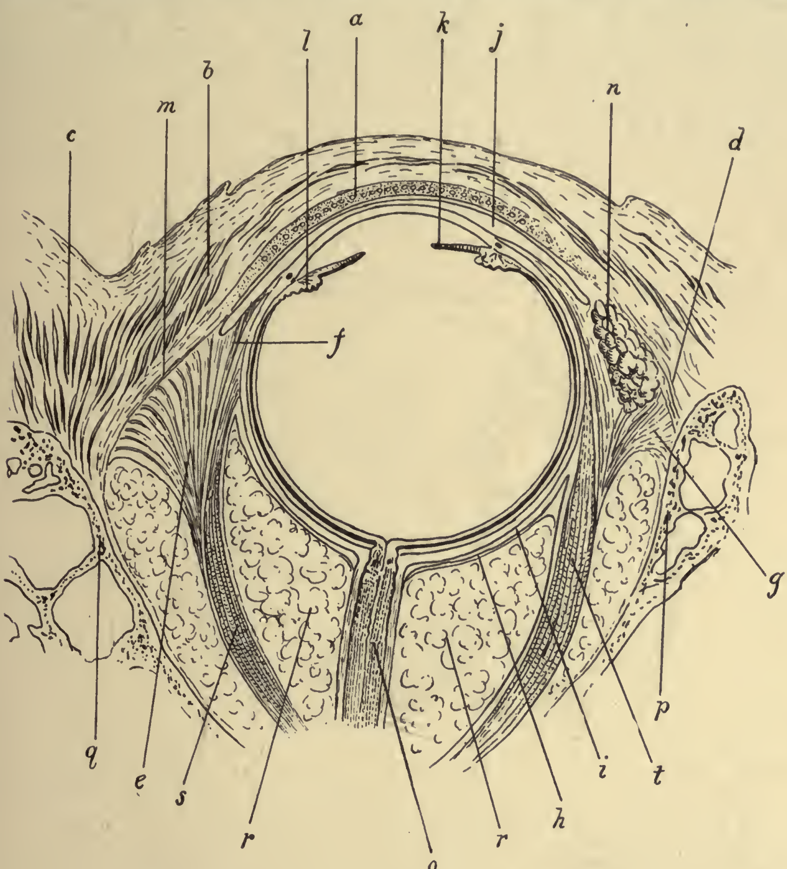

Fig. 390.
Horizontal Section of Orbit.

a. Tarsus.
b. Orbicularis.
c. Muscle of Horner.
d. Outer palpebral ligament.
e. Inner check ligament.
f. Attachment of Tenon's capsule to conjunctiva.
g. Outer check ligament.
h. Capsule of Tenon.
i. Space of Tenon.
j. Conjunctival sac.
k. Iris.
l. Ciliary process.
m. Septum orbital.
n. Lachrymal gland.
o. Optic nerve.
p. Lateral wall of orbit.
q. Mesial wall of orbit.
rr. Orbital fat.
s. Internal rectus.
t. External rectus.

ternally, for three-quarters of its length posteriorly, it is separated from the outer wall, which is here formed by the great wing of the sphenoid, by a cleft called the spheno-maxillary fissure. Through this there pass the superior maxillary division of the fifth nerve on its way to the infra-orbital canal, the orbital or temporo-malar branch of the same nerve, the infra-orbital vessels, and some twigs from Meckel's ganglion. By means of this fissure the orbit communicates with the spheno-maxillary fossa behind and the zygomatic fossa to the outer side. The floor is limited internally from behind forwards by the orbital process of the palate bone below; by the body of the sphenoid above and behind; and by the os planum of the ethmoid above and in front. At the interior extremity of this line of sutures the inner edge of the orbital plate of the superior maxilla is notched and free between the point where it articulates with the lachrymal posteriorly and the part from which its frontal process rises. Here it forms the outer

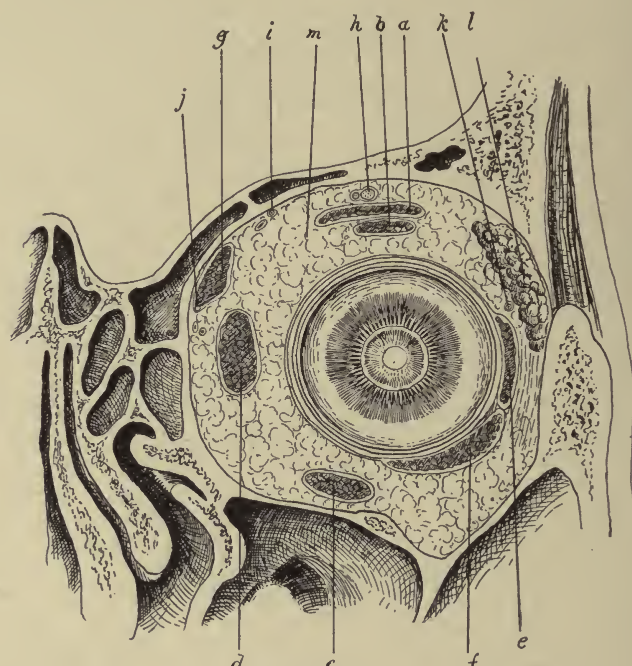

Fig. 391.

Coronal Section through Right Eye and Orbit.

a. Levator Palpebrae.
b. Superior rectus.
c. Inferior rectus.
d. Internal rectus.
e. External rectus.
f. Inferior oblique.
g. Superior oblique.
h. Supra-orbital nerve.
i. Supra-trochlear nerve.
j. Infra-trochlear nerve.
k. Lachrymal gland.
l. Temporal muscle.
m. Lachrymal nerve.

edge of a canal, down which the membranous lining of the lachrymo-nasal duct passes to the nose.

The floor of the orbit is thin behind and at the sides, but thicker in front where it blends with the orbital margin. Passing through its substances is the infra-orbital canal, the roof of which is usually deficient behind, where it becomes continuous with a broad, shallow groove, that leads forwards from the anterior margin of the spheno-maxillary fissure. This

canal opens on the facial surface of the superior maxillary immediately below the orbital margin and transmits the superior maxillary division of the fifth nerve, together with the infra-orbital vessels. The floor forms a thin partition which separates the orbit from the antrum or sinus of the superior maxilla, which lies below. Internally it completes the lower ethmoid cells, and separates the orbit from the middle meatus.

The *outer wall of the orbit*, which is the strongest, is formed by the orbital surface of the great wing of the sphenoid and the upper part of the orbital surface of the malar bone. Above it, behind, is the sphenoidal fissure, whilst below and extending much farther forward, is the spheno-maxillary fissure, to both of which reference has already been made. The anterior margin of the outer wall is thick and strong. It is formed by the malar bone, behind which, formed in part by the orbital process of the malar bone and the malar edge of the great wing of the sphenoid, it forms a fairly thick partition between the orbit in front and the temporal fossa behind. This wall is pierced in front by one or two small canals through which pass the temporal and malar branches of the orbital portion of the superior maxillary division of the fifth nerve.

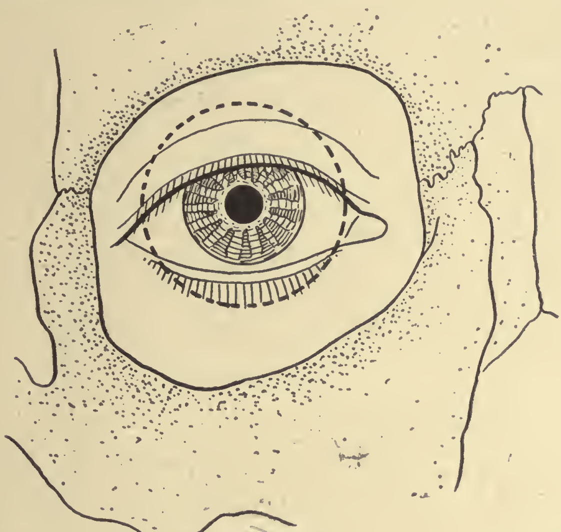

Fig. 392.

The Relations of the Anterior Ocular Apparatus and the Eyeball to the Orbit. (After Merkel.)

The *inner wall of the orbit* is formed (from before backwards) by the frontal process of the superior maxilla, the lachrymal bone, and by the orbital plate of the ethmoid. Posteriorly, one sees a small portion of the lateral aspect of the body of the sphenoid in front of the optic foramen.

The lachrymal and the orbital plate of the ethmoid articulate with the orbital plate of the superior maxilla below; posteriorly the extremity of the os planum and the fore part of the body of the sphenoid articulate with the orbital process of the palate.

The orbital surface of the lachrymal bone is divided into two by the lachrymal crest, vertical ridge which forms in front the posterior half of a hollow, the *lachrymal groove*, the anterior part of which is completed by the posterior border of the frontal process of the superior maxilla. In this fossa is lodged the lachrymal sac, whilst passing from it and filling the canal is the membranous portion of the nasal duct. The extremely thin wall of the lower part of the lachrymal fossa separates the orbit from the anterior portion of the middle meatus. To the inner side of the upper part of the lachrymal bone, and separated from the orbit merely by the thick-

ness of that bone, is the passage leading from the nose to the frontal sinus *(infundibulum)*. The segment of bone behind the lachrymal crest forms the thin partition between the orbit and the anterior ethmoid cells. Behind, where the body of the sphenoid forms part of the inner wall of the orbit, the sphenoidal air sinus is in close relation to the apex of that space. Here the partition between the two cavities is much thicker.

The Orbital Axes.

In most Aryan races the crossing of the axes behind makes an angle of about 42° which corresponds, of course, to 20° with the median plane of the head. The *bases of the orbital pyramids* do not lie exactly in the same frontal plane, but make with one another an angle that varies greatly in individuals but strikes an average of 147° in men; slightly less in women.

The *size of the orbit* varies greatly according to the age, sex and racial origin of the individual. Czermak[2] gives the following averages for Europeans:

Depth of the bony cavity,	39.4 to 50 mm.
Men	43 mm.
Women	40.55 mm.
Width at the base, men	40.5 mm.
Width at the base, women	40 mm.
Height of the facial opening, men	35 mm.
Height of the facial opening, women	34.5 mm.
Distance between the orbital axes at the base of the orbit	62 mm.

To calculate the depth of the orbital cavity on the living subject the same author advises the measurement of the space between the first upper molar tooth and the posterior aspect of the wisdom tooth, which corresponds to the length of the inner orbital wall.

The *periosteum* covering the orbit is thin and delicate. It not only lines the various openings that lead into or out of it but becomes one of the coverings of the nerves and blood-vessels that pass through them. These include the *optic foramen* and the *superior orbital fissure* which, communicating with the cranial cavity, are continuous with the dura mater. In the same way this periorbital membrane extends through the floor of the cavity to the temporal fossa and pterygo-palatine and by way of the lachrymal duct to the nose. As a rule the orbital periosteum is very loosely attached to its bony surroundings. Only in the region of the sutures, the orbital openings and on the margins of the cavity is it closely applied to the osseous structures—a fact that should be borne in mind in operations involving this tissue. It must be remembered, also, that it sends fibres into and

[2]Czermak. *Augenärztliche Operationen*, I, p. 370.

about the soft tissues that fill the orbit—the muscle fascia, the fat bundles, nerves and blood-vessels.

The contents of the orbit are, besides the *eyeball,* and its appendages, the *lachrymal glands,* numerous *bloodvessels,* many *nerves,* considerable *connective tissue,* and a rather large pad of *orbital fat.*

Anesthetics in Orbital Surgery.

The various anesthetics generally indicated in ophthalmic operations are detailed at length in Reber's chapter. To his observations may be added the statement that the majority of surgical procedures advised for diseases of the orbital walls and contents requires, for obvious reasons, a general anesthetic. Several surgeons employ local anesthesia in various forms, especially when the ocular or systemic conditions are unfavorable to the use of ether, chloroform, nitrous oxide, etc. Loewenstein believes that an injection of cocaine solution directed towards the ciliary ganglion influences all the sensitive nerves of the eyeball and orbit. He also quotes Elschnig who performed 26 operations under *ganglion anesthesia,* viz. 18 enucleations, 7 exenterations and 1 cyclodialysis.

After *cocainization of the conjunctiva a Pravaz* (*hypodermic*) *syringeful of a 1 per cent solution of cocaine is injected through a strong needle 5 cm. long.* The lateral commissure is stretched towards the temple and the needle introduced through the conjunctiva, close to the lateral orbital margin a little below its middle point. It is then carried along the lower border of the external rectus muscle and external orbital wall, and finally lifted inwards until about 0.5 cm. of its shaft is still visible; and one-half a syringeful is injected. By slight side-to side motions one must guard against the needle point being caught in the optic nerve or a large blood vessel. The anesthesia of the eyeball, which ought to be established within two minutes, is tested by slight pressure on the globe. If the eyeball is not anesthetized the needle is pulled back about 1 cm. and reintroduced in a changed direction. Subconjunctival injections of cocaine, about 15 mm. from the limbus, are also made in inflammatory cases. Most patients were given 0.01 morphin half an hour previously, which had a beneficial psychical effect.

There was little or no pain in eleven of thirteen cases operated on and in none of them was a bad effect from the cocaine observed.

Exploratory Puncture.

Before considering single operations on the orbital walls and contents it is desirable to discuss a few procedures that are common to almost all divisions of orbital surgery.

Exploratory puncture is employed for determining the character

of tumors or other abnormal deposits in the orbit. It may be done with a *grooved needle,* a small *hypodermic syringe,* an exploratory *trocar, a narrow Graefe knife* or a *pointed bistoury.*

Billroth[3] employed an *acupuncture needle* to determine, *in the case of tumors,* whether the bony walls of the orbital cavity were still intact. The needle is thrust deep enough and in such a direction as would in the normal condition reach the osseous structures. If no resistance is felt the conclusion is that the bony wall has been absorbed by pressure of the neoplastic growth and that the neoplasm probably extends beyond the orbit, perhaps, for instance, into the cranial cavity.

Incisions.

Dividing the overlying tissues with a suitable knife is employed for the drainage of fluid or the removal of solid or semi-solid material such as orbital cysts and abcesses. It is also useful in suppurative periostitis, empyema or dropsy of the frontal sinus or ethmoid cells, as well as for hemorrhage into the orbit or beneath its periosteum. It is likewise employed for the removal of splinters (in fracture of the cranial bones) and foreign bodies; also as a preliminary to the extirpation of tumors. It is also resorted to in cutting open the fistulæ accompanying lachrymal and frontal sinus disease.

The *form of incision* depends upon the purpose of the operation—whether it be *through the palpebral skin or by way of the conjunctival sac.* The latter route is preferable because there remains no visible scar; still the orbital cavity is less accessible in this procedure and the wound cannot long be prevented from healing by the introduction of a tube or gauze drain because these dressings act as an irritating foreign body to the conjunctiva and cornea.

The *conjunctival incision* is made in and parallel to the fornix, is employed in cases where only a temporary wound is required, as in the removal of foreign bodies and splinters of bone that can be felt through the conjunctival sac, as the first act in the extirpation of tumors and in some operations on the lachrymal gland.

The *palpebral skin incisions* should be governed by the rules laid down by Wilder in the chapter on Operations on the Eyelids. As a matter of fact they generally follow the outline of the orbital margin. When the foreign body or tumor is superficial the lid skin is stretched between the thumb and forefinger of the left hand while the point of a convex scalpel, directed at right angles to the skin surface, is passed through the tissues to the required depth and a clean, uniform cut made from one side to the other of the bulging body. It is more surgical to make too long a primary incision than one that requires

[3]Billroth. *Chirurg. Klinik in Wien,* 1870.

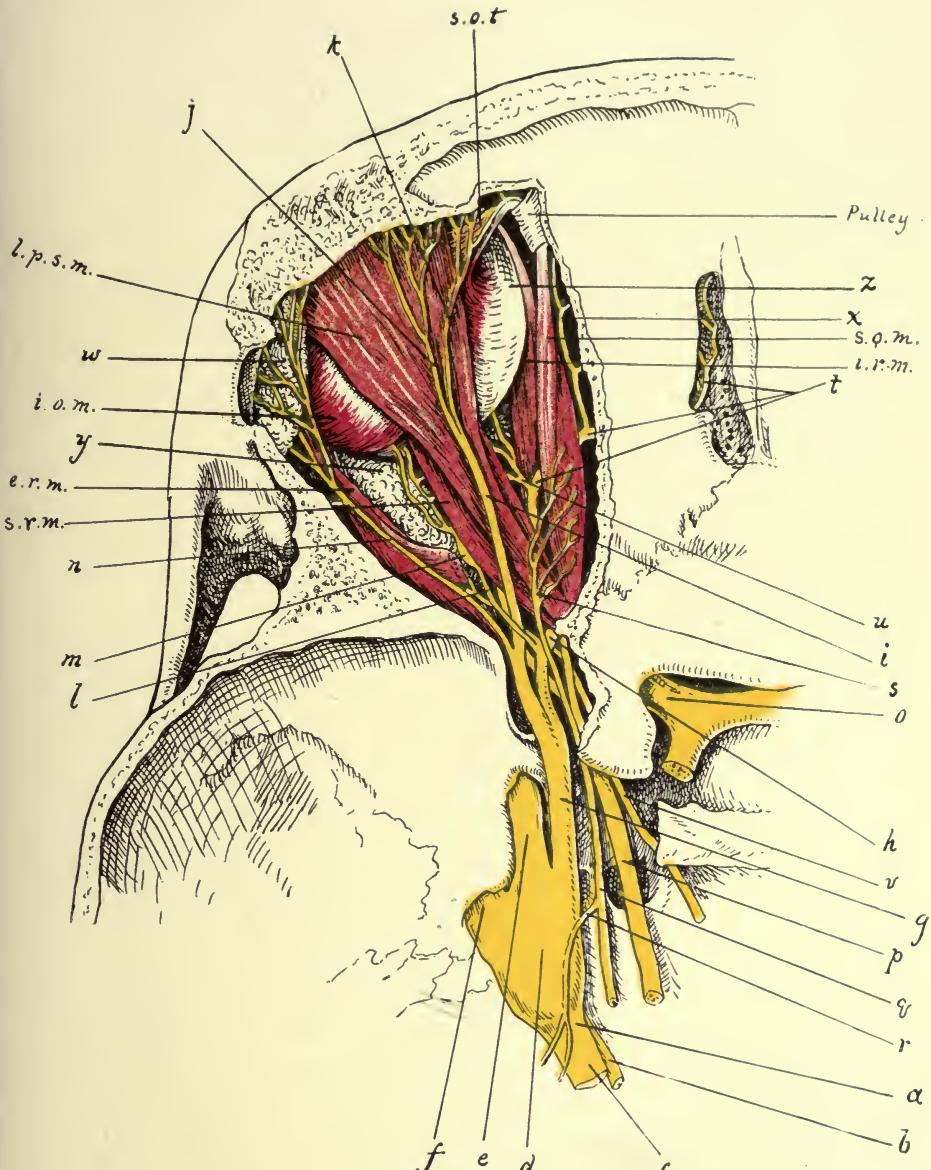

PLATE VI

Nerves, Muscles and Other Contents of the Orbit.

a. Fifth cranial nerve. b. Motor root. c. Sensory root. d. Gasserian ganglion. e. Superior maxillary nerve. f. Inferior maxillary nerve, g. Opththalmic division of the fifth cranial nerve. h. Nasal nerve. i. Frontal nerve. j. Supraorbital nerve. k. Supratrochlear nerve. l. Sensory root of lenticular ganglion. m. Lenticular ganglion. n. Lacrymal nerve. o. Optic nerve. p. Third cranial nerve. q. Fourth cranial nerve. r. Recurrent branch of fourth nerve. s. Branches of fourth nerve. t. Nasal nerve. u. Long posterior ciliary nerve. v. Sixth cranial nerve. w. Lacrymal gland. x. Infratrochlear nerve. y. Orbital fat. z. Eyeball. l.p.s.m. Lavator palpebræ superioris muscle. s.r.m. Superior rectus muscle. s.o.m. Superior oblique muscle. s.o.t. Superior oblique tendon. i.r.m. Internal rectus muscle. e.r.m. External rectus muscle. i.o. m. Inferior oblique muscle.

subsequent lengthening. Subsequent incisions following the whole length of the primary cut are now made until the tumor in its capsule is reached.

In choosing the *site of an incision by way of the conjunctival sac* it is best, if one has a choice, to elect the lower-outer aspect of the eyeball, thus avoiding what in the other localities might involve the tendons of the internal rectus, the superior oblique and the inferior oblique as well as by no means of least importance—the eyeball itself.

The *depth to which the incision is made* will depend largely upon the resistance of the parts. Great care should, of course, be exercised in performing the operation and, above all, *one must remember the depth of the orbit* and never allow the point of the knife to reach the apex of the cavity.

Orbital Abscess.

Purulent collections within the orbit should be opened and drained at the moment (and in the situation) that fluctuation is first noticed. When eyesight or life itself—or both—is endangered by a septic collection within the orbit it is desirable to cut down upon it before fluctuation can be detected, in which case one must be guided as to the position and extent of the incision by the direction in which the globe is pressed, the character of the excursions, the variation in the resistance of the tissues about the eyeball and, lastly, by the *sign of Uszynski*[4]—the indentation of the eyeball as determined by the ophthalmoscope.

J. J. Evans[5] points out that orbital abscess of antral origin usually shows at the lower-outer margin of the orbit; if from the frontal sinus at the upper-inner third of the margin—as has been noticed for a long time by others. The anterior ethmoidal cells correspond to the anterior half of the nasal wall of the orbit; the posterior half to the posterior cells.

Foster[6] reports a case where incision into the orbit led to the discovery of pus that seemed to come from the inner wall of the cavity and the adjoining nasal cavities. Finally, repeated incisions revealed the zygomatic fossa as the seat of the disease, the pus stream having entered the orbital cavity through the spheno-maxillary fissure.

In urgent cases—where rapid increases of swelling, high temperature and other evidences of serious infection of the orbit declare themselves, even when one suspects the presence of a localized deposit, the foregoing observations are generally insufficient to indicate the exact locality of the septic depot. In these instances a horizontal blepharotomy should be performed and several incisions made deep into

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[4]Uszynski. Beitrag zur Kasuistik retrobulbar Abszesse. *Klin Monatsbl. für pkt. Augenheilk.*, 30, 1892, p. 110.

[5]Evans. Ocular and Orbital Complications of Disease of the Accessory Sinuses. *The Ophthalmoscope*, April, 1908.

[6]Foster. Abscess in the Zygomatic Fossa. *Annals of Ophthal.*, July, 1908.

the orbital tissues to relieve the edema, permit the escape of fluids and perhaps, tap the poisonous collection. Axenfeld even advises, in these desperate cases, a Krönlein operation which may expose the infected locality, permit a more thorough exploration of the orbit, the evacuation of pus and the relief of the most urgent symptoms by removing pressure on the swollen tissues. This procedure is preferable to any of the operations for opening the orbit from the nose.

Whatever means is employed for cutting down upon the septic deposit a careful search with the finger and sound should be made for disease of the bony walls of the orbit, unless another and definite diagnosis has been made. If caries or necrosis of the superior orbital wall is established the greatest precautions are to be observed and in all cases it must be remembered that the frontal sinus and the cells of the ethmoid are frequently involved in septic abscesses, phlegmon and other processes within the orbit.

Extirpation of Orbital Tumors.

In the removal of growths of this situation one should bear in mind their *size,* their *situation,* (whether they rest in the anterior or posterior segment of the cavity, whether they are within or without the muscle cone), their *extent* (whether they involve or have spread from other cavities, their *boundaries* (whether circumscribed or diffuse), their *character* and their *origin.* Finally, the *state of the eye itself* should be taken into consideration.

Another important question is whether the tumor can be extirpated without removal of other tissues, or whether the eyeball itself may not also require enucleation?

It must at once be seen, from the foregoing, that definite rules for dealing with *orbital growths* are difficult to formulate—only the principles that should guide one can be laid down. During the operation, also, it may be necessary to vary the first plan adopted. The surgeon should, therefore, obtain the consent of the patient to the removal of the eye, should he consider it necessary, before the operation is begun and especially before the employment of a general anesthetic.

For small, *benign tumors, in particular cysts*—situated above and well towards the front of the orbit, between the muscle cone and the levator of the lid—one should choose the incision through the conjunctival tissues at the fornix following the margin of the orbit. This procedure is confined to benign tumors. The second operation, *through the lid skin,* is employed for the removal of benign growths within the muscle cone—fibromata and cystic tumors—as well as neoplasms of the optic nerve itself.

In the case of large tumors situated outside the muscular cone, especially those between the cone and the levator palpebræ, a combin-

ation of the lid section and the Krönlein operation greatly increases the efficacy of the former procedure. This combination not only increases the area of the operation but avoids the danger of injuring the eyeball. When possible, the skin incision should follow the upper margin of the orbit.

When one has to deal with *malignant neoplasms,* especially with those involving or threatening the globar tissues, quite a different method should be chosen, if, indeed, any operation is considered. This matter will be more fully considered under Exenteration of the Orbit.

As a rule *cystic and solid tumors* of the orbit operable under the rules (q. v.) just laid down are easily extirpated. The section in the skin is made just within the hair of the eyebrow when possible, so as to conceal the scar, and if the tumor has a capsule it should not be incised, but removed with the growth.

When the section is made through upper or lower sulcus more room may be secured by a *canthotomy* (q. v.) The conjunctival incision having been made with a small convex scalpel, the operator continues the cut to the outer canthus, or *vice versa,* a method of especial value in tumors occupying the outer-upper or outer-lower quadrants of the orbital base. After the primary incision the wound edges should be separated by broad elevators, an Allport's speculum (q. v.) or similar instrument and the cutting continued with some care. The small arteries severed during the operation should be tied or fixed with small hemostatic forceps. As soon as the tumor is reached the knife should be laid aside and the growth isolated from its bed by the fingers, a blunt spoon, strabismus hook or closed scissors, not forgetting to enlarge the deep wound so that its width corresponds to the superficial incision. By this careful form of enucleation the growth is meantime grasped and gently dragged forward with forceps or by means of a suture through its capsule, is detached from its surroundings, avoiding the use of cutting instruments except that fibrous bands are best severed with scissors close to the tumor mass. It must be remembered that it is important to *remove all the tumor tissues.* Care should be taken not to injure by undue pressure or otherwise the neighboring eyeball and optic nerve.

When, as in the case of *dermoids,* the neoplasm is firmly attached to the orbital wall, i. e. to the orbital bones it is advisable after detaching it with scissors to curette the point of attachment; if to the periosteum alone it is sometimes possible to remove that portion attached to the tumor with raspatorium.

Having removed one tumor it must *not be assumed that it is the only one present.* A second or even a third may be concealed by a

more superficial growth, as has been observed by several writers. Instructive papers on this subject have been contributed by Badal[7] and Cornwell.[8]

Oram Ring[9] draws these conclusions regarding *sarcoma of the orbit and its surgical treatment:*

1. The difficulty in accurate diagnosis under certain conditions entirely justifies an exploratory incision with removal of a section of the growth for microscopic study, said exploration likewise serving to determine the ramifications of the tumor.

2. The brilliant results achieved by a number of accurate observers in the field of Roentgen therapy justifies the immediate tentative application of the method before any radical operation is attempted. If unsuccessful in removal of the growth, its virulence will probably be decreased and the dangers of metastasis lessened. (Leonard).

3. If the sarcoma is encapsulated, operative intervention without (complete) orbital evisceration promises a successful outcome.

4. In view of the almost constant recurrences after orbital evisceration, the removal of the growth itself is regarded as sufficient unless the periosteum or bony wall is involved.

5. The encouraging results reported from the cataphoric sterilization of malignant growths in other parts of the body seem to warrant the utilization of this method in the orbit, due care being exercised as to strength of current used.

6. Future experience must determine whether better results will be achieved by using this method for the original growth or reserving it for recurrences in loco.

7. If operation has been performed and the growth has recurred, we have at command these two valuable methods of attack.

The indications for the *operative treatment of orbital tumors in general* are pretty thoroughly discussed by Wurdemann[10] and others, Stedman Bull among the number. The latter believes that if an orbital tumor is developed in the orbital tissue proper, in the sheath of the nerve or in the periosteum, and is *encapsulated*, the prognosis is good; if it is not encapsulated, no matter what its origin, the prognosis is bad. He believes that each operation tends simply to hasten the return of the growth and by so much to shorten the life of the patient. He was favorably impressed with the value of X-ray treatment under these circumstances.

Operations for the Removal of Tumors of the Optic Nerve.

The removal of optic nerve tumors by the subconjunctival route was first fully described by Lagrange[11].

After general anesthesia he did an external canthotomy and passed a suture through each lid so that it might be used as a retractor. Then the outer half of the bulbar conjunctiva and Tenon's capsule was dissected to the sulcus, the tendon of the external rectus divided and a thread passed through the distal portion—so as not to lose sight of it. Then, by means of the index finger or a sound (closed blunt scissors make a useful instrument for the purpose. W.) the tumor is isolated from its surroundings, the

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[7]Badal. Fibroscarcoma kystique du fond de l'orbite. Extirpation avec Conservation de l'oeil. *Archives d'Ophtal.* Vol. 13, p. 193.

[8]Cornwell. Eine Jenische Dermoidzyste der Orbita. *Archiv f. Augenheilk.*, Vol. 14, p. 120.

[9]Ring. Sarcoma of the Orbit. *Trans. Oph. Sec. Coll. Phys.*, Philadelphia, 1904.

[10]Wurdemann. Tumors of the Eye and Orbit. *Jour. Am. Med. Ass'n.*, Dec. 17, 1904, p. 195.

[11]Lagrange. De la conservation du globe oculaire dans l'ablation des tumeurs du nerf optique. *Recueil d'ophtal.*, May-June, 1892. See, also, his article, De la conservation du globe de l'oeil dans l'extirpation des tumeurs du nerf optique. *Congrés français de chirurgie*, **Paris, 1892.**

globe being pushed to one side and kept there by a spatula or an enucleation spoon (q. v.).

Having separated the tumor from the surrounding muscles, etc., a (Cooper's) needle armed with a stout silk ligature is passed around the neoplasm; and, if necessary, it is transfixed by another thread for the purposes of better manipulation. Now, with guarded scissors (so as to avoid the ophthalmic artery), guided by the finger, the nerve is cut through at the orbital apex. By firmly pulling on the ligature and transfixing suture the eye, tumor and nerve may be extruded from the orbit and retroverted. The nerve and tumor may now be cut off close to the globe and the posterior aspect of the latter examined. The bleeding is arrested, the parts rendered aseptic, the globe is turned around and replaced in its socket; the external rectus is resutured, the ocular coverings replaced and the wound edges in them and in the lid sewn up. Drainage is provided for several days but, as a rule, the swelling in the parts soon subsides and there is little subsequent reaction.

The globe follows the usual rule of optic nerve resection, as described in Dr. Allport's chapter. The eye shrinks, the cornea loses its lustre, the pupil its reaction and the globe its normal tension. However, the result is generally better than after a partial orbital evisceration or even a globar enucleation. Moreover, the shrunken globe forms a good pad for a prothesis should that expedient eventually be chosen.

If, owing to the unusual size of the new growth it is difficult to withdraw it from the orbit it may be necessary to cut through the superior and inferior rectus after a corresponding removal of the overlying conjunctiva.

During the *after conduct* of these cases *complications may arise* that necessitate enucleation of the eyeball. Hemorrhage may force the eyeball out of the orbit and prevent its reposition. If it sets in immediately after the operation the lids may be sewed together over the globe in the hope that the pressure upon the soft parts may stop the bleeding.

Neuroparalytic keratitis is another complication which may end in destruction of the cornea, hernia of the iris and phthisis bulbi.

Braunschweig believes that the best way to avoid most of these dangers is always to do a Krönlein operation. The external rectus, when exposed, may either be pushed aside, two sutures being passed through its upper and two through its lower border. These sutures are tied and the muscle divided perpendicularly between the knots. The nerve and tumor are shelled out with the finger and treated as in the Lagrange method (q. v.).

It must be remembered, in connection with every form of optic neuroma that the eye affected is always blind and *that the question of removing the tumor without sacrificing the globe is generally a cosmetic one.* If the tumor is not too large or too diffuse it can generally be extirpated without sacrifice of the globe.

If it extends into the cranial cavity it is best not to attempt its removal.

Knapp[12] has described two successful operations for the extirpation of optic neuromata. He introduced an ordinary eye speculum and with a pair of strabismus scissors made an opening, up and in, along the superior fornix through the conjunctiva and Tenon's capsule between the superior and internal rectus and the superior oblique until he could outline the optic tumor with his forefinger. Under the guidance of the index finger he severed the attachments of the growth from all the surrounding tissues except the optic nerve. Finally, he cut through the nerve itself, first at its ocular, then at its distal end, and succeeded in drawing out the entire growth with the flat of the scissors. There was very little bleeding.

If it can be established *that the tumor affects only the nerve sheath* an attempt may be made to remove the new growth without damaging the nerve itself—and so preserve or recover some eyesight—especially as neuromata in other situations have been extirpated without entire loss of the nervous function, although it seems impossible to preserve the central vessels uninjured and, failing that, blindness is inevitable.

Although tumor tissue is often observed in the distal end of the cut nerve showing that the intracranial portion was involved, the majority of primary optic tumors are benign and do not return after being treated in this way. Salzmann[13] has published an account of three cases of myxosarcoma (the commonest form of optic nerve tumors) in which he shows that they exhibit no disposition to perforate the orbital walls or to involve distant organs. In a very few cases the tumors are of the pure sarcoma and endothelioma type and require an entirely different surgical procedure.

Finally, Byers [14] has given a full account of *primary intradural neoplasms* of the optic nerve which is well worth perusal by anyone desiring complete information on this subject.

As an example of the necessity for individual action in certain cases of orbital tumor, I was consulted in 1907 by a man, æt. 36, who had, several years before, lost his left eye by an accident. When I saw him he had a well developed carcinoma of the right lower lid and internal angle that had been treated with Vienna paste, X-rays and by various cutting operations. The inner half of the lower lid, the tissues at the internal canthus and the inner fifth of the margin of the upper lid were bound together in one cicatricial mass. So far as could be made out by a nasal examination there was no involvement of the ethmoid or antrum of Highmore, although from the symptoms and after skiagraphy there was suspicion of an extension of the cancer to the inner orbital wall and the inner-lower bony margin of the orbit. The globar excursions were greatly limited and the inter-palpebral fissure was reduced one-half; but vision was almost normal. I made a careful resection (with scalpel, blunt scissors and curette) of all the suspected tissues in the neighborhood and found that the malignant growth involved the inner wall of the orbit (which I removed) but that it was impossible without sacrifice of the eyeball to make a thorough exploration and cleaning out of the infected cavities.

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[12]Knapp. Extirpation einer Sehnervengeschwulst mit Erhaltung des Augapfels. *Klin Monatsbl. f. Augenheilk.*, 12 p. 439. Also Tumor of the Optic Nerve, *Trans. Am. Oph. Soc.*, 1879, p. 557.

[13]Salzmann. Studien über das Myxosarcom des Sehnerven. *Archiv, fur Ophthal.*, 39, 4, p. 94.

[14]Byers. The Primary Intradural Tumours of the Optic Nerve: Fibromatosis Nervi Optici. *Studies from the Royal Victoria Hospital*, Montreal, Vol. No. 1, p. 3.

The wound of operation healed kindly and with the subsequent implantation of several Thiersch grafts the patient's appearance and comfort improved.

In three months there was a manifest return of the disease with involvement of the ethmoid spaces. The patient was then given the choice of complete blindness or a *chance*, by a complete orbito-ethmoid exenteration, of escape from impending death through extension of the neoplasm to the brain and general system. The unfortunate man chose the latter alternative and died about 18 months afterwards.

Exenteration of the Orbit—Evisceration of the Orbit.

Extirpation of the orbital contents may be *partial* or *complete* and either operation is required when enucleation or an osteoplastic resection is insufficient to eradicate the orbital disease.

George Bartisch[15] was the first to describe the medieval method for exenteration of the orbit. He gives full illustrations of the instruments employed and describes the operation, which consisted in cutting, gouging and scraping the orbital contents, with the tumor (for which the operation was then, as now, most commonly done) out of the socket.

The modern form of orbital exenteration was introduced for the first time by Arlt[16].

Partial evisceration is indicated in cases where only the soft parts are affected and includes enucleation of the eyeball and removal of certain other tissues of the orbit as, for example, a growth that threatens the integrity of the surrounding parts or the life of the patient. Some examples of this incomplete form of exenteration are described under *operations on the orbital walls* but in general the operation may be said to be required in epithelioma that has extended into the orbit, in the circumscribed forms of orbital sarcoma, in all malignant tumors that are confined to the muscle cone and in slight extensions of intraocular neoplasms through the scleral walls. In other words, the exenterated tissues are only those directly involved in the disease.

As complete exenteration is not an operation to be lightly undertaken, owing to the deformity that follows, it is well in some cases not to decide whether the severer intervention is required until the operation is well under way, since the simpler plan may be substituted for total exenteration during any stage of the partial operation.

Complete or Total Evisceration or Exenteration of the Orbit.

This serious procedure involves complete extirpation (under appropriate general anesthesia and the most careful asepsis) of the orbital contents and often includes excision of one or both lids. The entire periosteal lining is generally removed and sometimes the operation

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[15]Bartisch. *Ophthalmodouleia*, 1583, chapter 3, p. 208.

[16]Arlt. Operationslehre. Graefe-Saemisch. *Handbuch der ges. Augenheilk.*, 1 Ed. Vol. III, 1, 1874, p. 434.

involves the opening and cleaning out the frontal or other neighboring cavity.

If the lids are to be preserved intact a *canthotomy* is first done to expose the outer margin of the orbit. This enables the operator's assistant to hold the palpebral borders wide apart with lid elevators or tenacula. With a stout convex scalpel the soft parts are incised down to the bone all about the orbital margin. To avoid as long as possible obscuration of the operative field the lower border corresponding to the inferior formix, is first incised; then, following the left forefinger, as a guide, the upper and outer borders receive similar attention. Now, if it is decided to do a *total exenteration from the beginning* the marginal periosteum should be lifted away from the bone with a raspatorium and the whole of the orbital cone, contained in it, (vessels, nerves, fat, muscles, eyeball, etc.) are carefully separated by curved scissors, curette, handle of the scalpel and the forefinger, in one mass from the bony walls to the extreme apex of the orbital pyramid. In addition to these, all ramifications of the diseased tissues should be extirpated.

Unless they are involved in the disease we should spare the lachrymal sac and its extension into the nasal duct. The lachrymal gland is also avoided, although the latter is often eviscerated in the complete operation. The separation of the periosteum will be most satisfactory if carried out first on the temporal wall of the orbit, then above and finally on its inner aspect. Resistance to the elevation of the periosteum may be expected at the insertion of the internal check ligaments and the pulley of the superior oblique where the simple elevator or forefinger will have to be reinforced by the scissors. Care should be taken, while working in their neighborhood not to perforate the delicate bony walls of the orbit, especially at the thin paper-like lamina of the lachrymal bone and at the optic foramen, sphenoidal fissure and zygomatic fossa.

When the periosteal sac with its contents are entirely separated from the surrounding bony walls and are held in place only by the tissues about the foramina at the apex, they should be divided by a pair of scissors. Those instruments devised by Bettman and Worlomont (q. v.) are recommended since these combined scissors and clamp not only cut but serve to prevent bleeding which is often profuse.

The best method of limiting the hemorrhage attendant upon orbital evisceration is the gauze tampon and the hot bichloride douche, 1:3000. The latter may be freely applied and used as hot as it can be borne by the hand.

The best dressing for both partial and total evisceration is a long strip of gauze—iodoform after the removal of malignant growths, plain otherwise—gently packed and filling the whole cavity. It may be smeared with White's ointment[17] or with sterile vaseline to prevent adherence to the tissues. If the orbit be firmly and uniformly filled with the gauze it is not necessary to apply a roller (pressure) bandage, though it may be needed if the lids have been removed. It is well to change the dressing twice a day, douching the cavity with sublimate solution (1:3000) each time before applying the gauze.

The exenterated orbit soon cicatrizes in part and eventually fills with granulations and some surgeons take advantage of the presence of these to impose upon them mucous or skin grafts (Küster[18] prefers skin flaps) both to protect the parts and to relieve somewhat the hor-

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[17]Wood's *System of Ophthalmic Therapeutics*, p. 579.

[18]Kuster. Die Deckung der Augenhöhle nach Ausraumung derselben. *Centralbl. f. Chirurgie*, 2 1890.

rible deformity resulting from the removal of the tissues. Some of these procedures are described in this chapter. This cosmetic object is attained to some extent by plastic operations intended to allow the patient to wear a prothesis—a subject discussed in the chapter by Beard on the restoration of conjunctival cul-de-sacs. In total extirpation simple procedures are of little avail and this is the reason why it is occasionally wise to rely upon some of the operations (q. v.) for complete obliteration of the conjunctival sac or occlusion of the orbit.

Generally speaking, *the ability to spare the lids and conjunctiva* is the chief factor in determining the character both of the orbital exenteration and of the subsequent operations. In the following pages it will be noticed that many of the surgical methods discussed hang upon this question.

For example, the *subconjunctival exenteration* described by Axenfeld[19] depends upon the salvation of all the lid structures, including their mucous lining. He does a preliminary enucleation in the usual fashion, then divides the conjunctiva horizontally to the inner canthus; *Externally all the lid tissues to the outer commissure are incised.* The orbital exenteration is now accomplished and the conjunctiva and lid skin carefully sutured. Subsequent treatment of the orbit is carried on through an enclosed medial opening corresponding to the recently removed cornea.

Should it be necessary to enlarge the usual sphere of the orbital evisceration on account of a large tumor, disease of the orbital walls or for involvement of the neighboring cavities, a more extensive detachment of the conjunctiva, as well as wider incisions in the lid skin may be made to meet the exigencies of the case.

Orbital evisceration done in this way lends itself to the wearing of a prothesis, especially if an artificial pad of paraffin, sponge, fat, iodoform-spermaceti, etc., can be inserted.

Busachi[20] prefers as an after-treatment of orbital evisceration a combination of the Thiersch and flap operations. First of all he covers the denuded cavity with epidermal grafts[21] and when these have "taken" he closes the cavity with flaps from the surrounding skin. The epidermal surface is turned inwards, the fresh surface being turned outwards and covered with Thiersch grafts.

Rollet[22] described a similar procedure, including removal of a portion

[19]Axenfeld. Ueber plastischen Verschluss der Orbita. *Bericht der 27 Versammlung deutscher Naturf. und Aerzte*, 1903.

[20]Busachi. Come si debba coprire la cavita orbitraria averla svuotata. *Riforma med.*, 1894, 4, p. 467.

[21]Van Noorden was probably the first to advise and describe this part of the method. See his paper, Ein Fall von Thierscher Transplantation der ganzen Orbitalhöhle, *Berlin Klin, Wochenschr.*, 4. 1891.

[22]Rollet. Occlusion de l'orbite et Suppression des paupieres. *Revue gen. d'ophtal.*, July, 1908, p. 289.

of the lids, and advises it especially for extensive burns and for malignant disease of the orbital tissues.

Romano-Catania[23] suggests a curious procedure, a study in facial cosmetics, when both lids are sacrificed. He brings forward two thick flaps from the cheek and forehead, including between them the strip of skin containing the eyebrow. In this way the supercilia are made to occupy the position of the interpalpebral slit—thus imitating the appearance of closed lids!

If the amount of excised tissue is not too great, the defect may sometimes be supplied by such a plastic operation as the conditions in individual instances may suggest. Even when the lids are entirely removed, sufficient skin may often be furnished by the dermal covering from the corresponding eyebrow and temple.

In any event, when an enucleation or exenteration is done for malignant disease, it is better to wait until the orbital wound has fully cicatrized (as that is the best way to insure complete extirpation of the growth) before covering the cavity by any of the methods proposed. Otherwise, the operations, especially those needing transplantation of skin, may be undertaken immediately after the evisceration itself.

Prothesis After Exenteration of the Orbit.

That an artificial eye may be worn in a cicatricial, contracted or obliterated conjunctival sac a number of operations have been devised. These include blepharoplasty and the transplantation of mucous, skin and other tissues after the manner of Wolfe, Thiersch, Gifford, Fricke, Hotz and others. They are described elsewhere (see the chapters of Beard and Allport in this *System)* and are mentioned here only to draw attention to the fact that the principles that underlie them are generally applicable to the similar treatment of an exenterated orbit.

For many reasons it is often best to close the orbital opening entirely after a complete exenteration, but *when the lids are preserved or after an operation for their restoration,* an attempt may be made—as in the Axenfeld operation just described—to fill up the cavity in such a manner that it will support a prothesis.

Polya[24] advises, for the purpose of providing a good, solid, pad for the artificial eye, the iodoform-spermaceti mixture described by Mosetig in this volume under the name "Knochenplombe."

After completion of the evisceration, when the hemorrhage has entirely ceased, the cavity has been thoroughly disinfected and is quite dry this artificial "bone" is poured in. The lids then receive necessary attention (are stitched over the spermaceti pad or it is covered by skin flaps) and drainage at one or both canthi is provided by means of iodoform gauze or threads. The spermaceti remains in situ, is soon covered by granulations, and acts as a non-irritating and persistent support of the prothesis.

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[23]Romano-Catania. Un nuovo processo di plastica per la copertura della caviet orbitraria nella exent. orbitae. *Archivio di Ottalmol.* Vol. I, 1894-5, p. 209.

[24]Polya. Abstracted from the Hungarian *Szemeszet*, No. 4, 1904. See *Michel's. Jahresbericht*, 1904, p. 367

When it is possible to preserve the lid-skin Golovine[25] suggests a method for supporting an artificial eye which (it seems to the writer of this chapter) might sometimes be combined with the plan of Pólya.

He first shapes a cutaneous flap (A) from the temple, as shown in the figure. A semicircular incision, *a-b*, is made and continued to *c*. Through a subdermal opening, that communicates with the orbit along *a-b*, the upper,

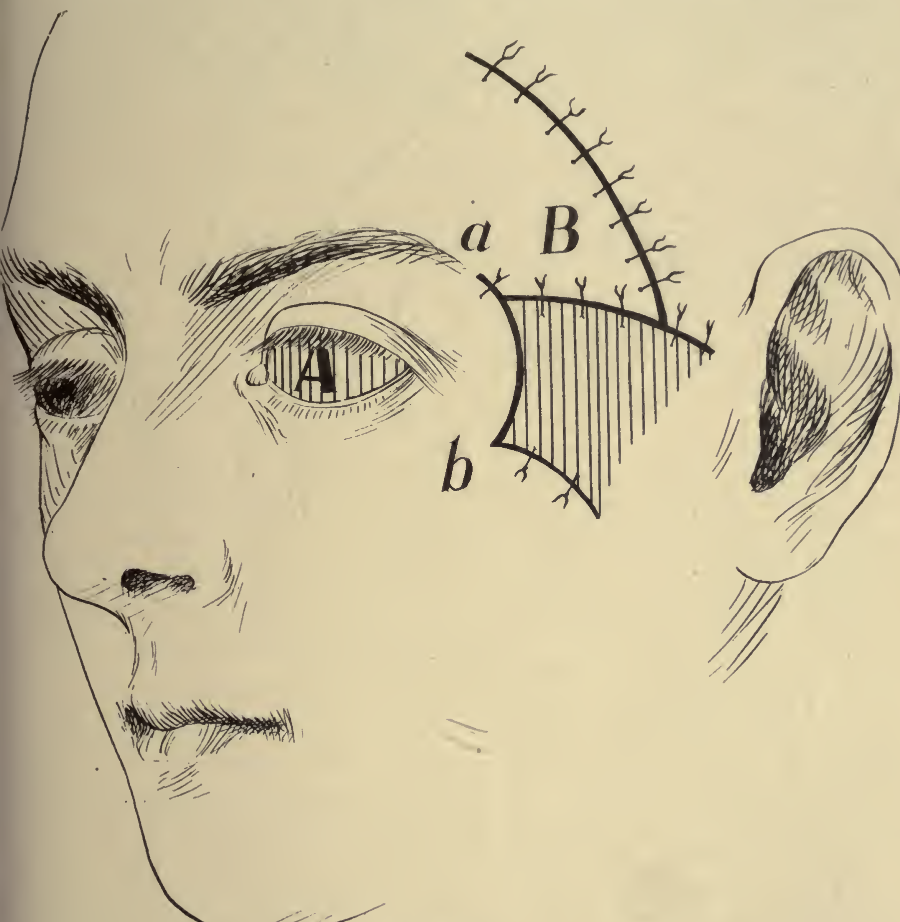

Fig. 393.

Golovine's Operation for Securing an Artificial Eye after Exenteration of the Orbit. The primary incisions.

rounded end of the large flap is slipped and the remaining tissues rearranged as in Fig. 393. The sliding flap, applied and arranged within the orbit (epithelial surface outwards) is carefully stitched to the cut edges of the remaining conjunctiva and so a space is formed in which the prothesis may rest.

[25]Golovine. Procédé de Cloture Plastique de l'Orbite aprés L'exénteration. *Archives d'ophtal.*, Nov., 1898, p. 679.

Operations for Covering the Interpalpebral Entrance and Relieving the Deformity Following Eyeball Enucleation and Orbital Exenteration.

If the lids are preserved, as in some enucleations of the globe and in partial exenteration of the orbit, the subsequent cicatricial contraction is prone to draw their margins inward and to add to the deformity.

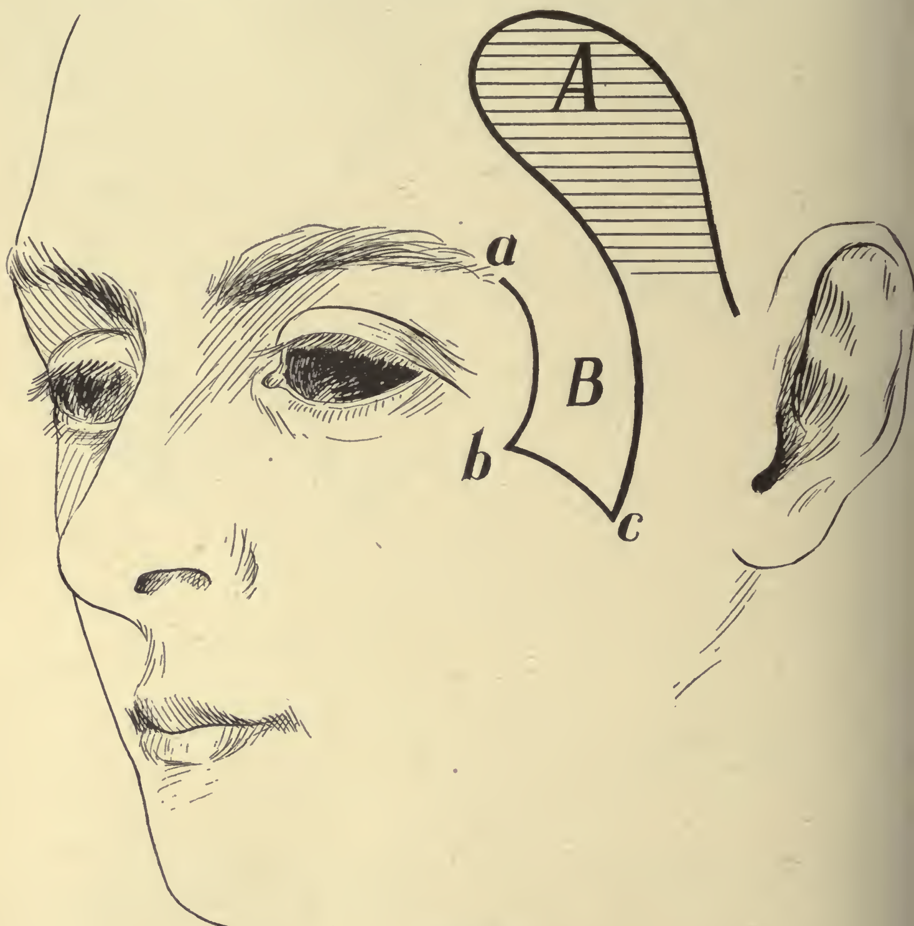

Fig. 394.
Golovine's Operation for Securing an Artificial Eye after Orbital Exenteration. Suturing the skin flaps in position.

Beard[26] was able in the case of a young woman with recurrent sarcoma of the lachrymal gland after enucleation and partial exenteration had been resorted to in vain, to save the lids and conjunctival sac. The incision extended from about 2 cm. below the outer canthus and

[26] Beard. *Ophthalmic Surgery*, p. 615.

around the superior margin to the median line of the nose. The flap thus outlined was dissected up without injuring the conjunctiva, the exenteration made and the flap replaced.

Still there are cases, especially following exenteration, in which it is not only impossible to wear an artificial eye but patients are much annoyed by the epiphora, conjunctival secretion and the disfigurement of the sunken lids and wide-open palpebral fissure. This unsightly and irritating condition is further aggravated by the fact that the lachrymal apparatus does not afford drainage for the tears and mucoid discharge that are sometimes secreted in abundance from the abnormal cavity.

Among the recorded attempts to remedy this sad state of affairs may be mentioned those of J. F. Streatfeild[27], J. Green, Alt, Edwyn Andrew[28], Küster and others. These surgeons mostly sought to remove the secreting surfaces and borders of the conjunctival sac and to close the naked orbital cavity.

The removal or destruction of the conjunctiva and the subsequent obliteration of the sac, intended to relieve the local infection and cover a disfiguring cavity, was first undertaken by J. F. Streatfeild. He states the case as follows:

"Some patients, again, are met with, whether in private or hospital practice, who either before or since the excision operation are quite incapable and cannot by any surgical method be made capable of wearing an artificial eye, even if they desire it; such are the cases of irregular cicatrisation within the lids, caused by wounds or burns, or ill-surgery, and producing obstinate entropion, strong cicatricial bands in any direction (that cannot be isolated by a probe passed beneath them) or a narrowing of the whole conjunctival sac or of the palpebral aperture by any of the above means. It is a disgrace to surgery not to close up the ugly chasm and it is easily done."

Streatfeild at first excised with forceps and scissors all the conjunctiva he could reach, and destroyed the remaining mucous membrane with caustics—zinc chloride, etc. Later, he suggested that it is desirable *at the time of an enucleation* or partial orbital evisceration to close the interpalpebral space and described the following successful operation he performed for the purpose:

"The lower lid being held down and strongly everted by the forefinger of an assistant, the conjunctiva was cut through close to the free margin of the lid, and dissected off the tarsal cartilage; the conjunctiva was next cut through at the outer and inner canthus. The globe was then drawn well downwards and the fold of conjunctiva between it and the upper lid dissected from the subjacent soft parts, but as the conjunctiva could not easily be separated from the upper lid it was left to be removed by caustics at some future time. In this manner all the conjunctiva, with the exception

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[27]Streatfeild. Extirpation of the Eyeball together with the Removal of the Conjunctival Sac. *Lancet*, Vol. II, 1872, p. 849. See, also, Destruction of the conjunctiva in cases of extirpation of the globe, Vol. I, 1872, p. 821.

[28]Andrew. Enucleation of the Eyeball with Obliteration of the Conjunctival Sac. *British Med. Journal*, Dec. 19, 1885, p. 1155.

just named, was dissected up. The extirpation of the globe was now completed in the ordinary manner. Later, he notes that the soft parts of the orbit are granulating and are drawing the lids closely to them."

John Green[29] by preparing and suturing the lid lining and margins has much improved these earlier operations which he and Alt[30] do in the following fashion:

The tarsal tissues and conjunctiva are drawn forth with forceps and resected from the skin and muscle. Then the lid margins are excised, all the lashes removed and the wounded edges perfectly coapted and carefully stitched together. The result is a continuous cutaneous surface covering the orbital entrance and presenting a barely perceptible linear scar where was once an unsightly opening. Alt believes that "the freedom from continued secretion and irritation from the unsightly empty orbital cavity, the fact that by covering the orbit new irritations and, perhaps, with them sources of relapses are definitely excluded, seem to make this mode of operating one which should be more frequently employed."

Evidently unaware of the prior and (in the Editor's opinion) more effective method of John Green, Andrew, in 1885, suggested the following improvement on the Streatfeild operation:

"An incision is made with scissors into the ocular conjunctiva, half an inch from the corneal margin, and this incision is carried around the ball; the conjunctiva is now freely detached all round, until the edges of the lid-cartilages are reached, when the conjunctiva at the inner angle of the eye, with the caruncle, etc., is most carefully removed, as this is the only part where some difficulty of healing sometimes takes place; the conjunctiva of the outer angle is now similarly dealt with, the edges of the palpebral angles pared, the cartilages entirely dissected away, and a sufficient strip of the free borders of the lids removed, to include all the roots of the lashes, and lastly the ball is excised; the lids are merely brought into apposition, or the palpebral opening may be lessened by one or two sutures at each end, leaving the centre for drainage. It is advisable that the various steps of the operation should be carried out in this order, so that the bleeding may less obscure these manipulations."

Orbito-Sinus Exenteration.

Golovine's Operation.

Golovine[31] has devised a plan for the *extirpation of those malignant neoplasms, especially epithelioma of the lids* that develop at the internal angle of the eye, penetrate the orbit and involve one or all the neighboring sinuses. The *ethmoid, maxillary and frontal sinuses* are particularly the object of this surgical intervention. It has for its object *the conversion of these cavities into a single large space,* thus allowing complete extirpation of the disease which otherwise would be extremely difficult or impossible to reach. *After thoroughly cleaning*

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[29]Green. An Operation for the Removal of the Eyeball, together with the entire Conjunctival Sac and Lid Margins. *Am. Jour. of Ophthal.*, June, 1884, p. 65. First communicated to the Am. Oph. Soc., in 1882.

[30]Alt. On the Removal of the Eyeball, together with the Tarsi, Conjunctival Sac and Lid Margins. *Am. Jour. of Ophthal.*, March, 1903, p. 69.

[31]Golovine. Exenteratio orbito-sinualis (procede d'extirpation des neoplasmes envahissant l'orbite et les sinus cranio-faciaux). *Annales d'oculistique*, Vol. 142, Dec., 1909. See, also, his article, Modifikationen von Orbital operationen, *Klin. Monatsbl f. Augenheilk.*, Jan., 1908, p. 100.

out the cavities in question, the opening is closed by extensive skin flaps.

Golovine divides the operation into the following steps:

Fig. 395.
Exenteratio Orbito-sinualis. Incision of the Soft Parts. (Golovine.)

1. Under proper general anesthesia and asepsis outline incisions (See Figure) are made about the diseased orbit, (a) the *internal vertical* following the lateral margin of the nose and reaching from a point 2 to 3 cm. above the glabella. (parallel to the naso-labial fold) to 1 cm. below the ala nasæ; (b) the *external vertical* incision, a slightly curved line shorter than but almost parallel with the first. It terminates below at the alveolar proc-

esses; (c) the *horizontal superior* incision joining line *a* with line *b* and corresponding to the upper border of the eyebrow; (d) the *horizontal inferior* cut depends somewhat upon the ravages of the tumor, but generally corresponds with the inferior margin of the orbit. It will be seen that the total incision takes the form of an H with double crossbars.

2. *Total exenteration of the orbit* (q. v.) is now done in the usual way, the parts being removed, if possible, in one package. The orbital walls can then be carefully examined and the ravages and extent of the neoplasm better determined.

3. *Exenteration of the sinuses.* In carcinoma beginning at the internal angle it is generally the internal and inferior walls of the orbital cavity that are involved and, consequently, the nasal and maxillary cavities are first and most frequently invaded. Hence it is upon these that Golovine first

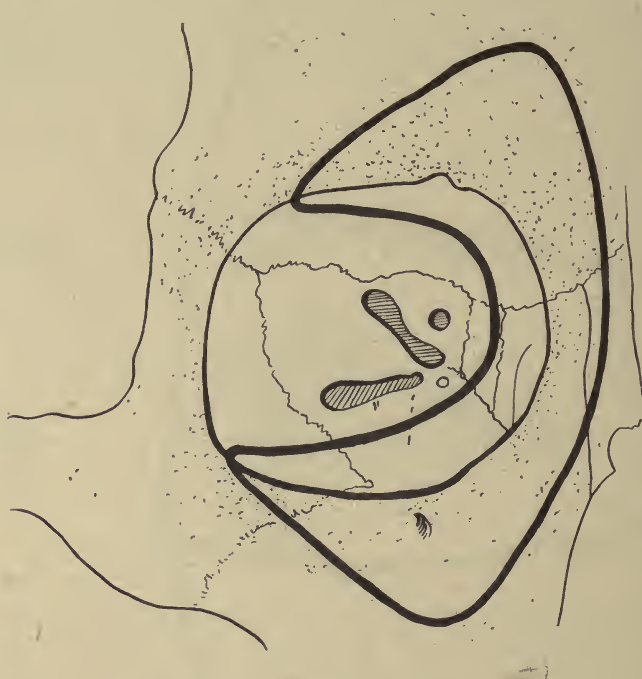

Fig. 396.
Exenteratio Orbito-sinualis. Line of Removal of Bony Parts. (Golovine.)

operates. With scissors and curette he raises successively the anterior and superior walls of the antrum of Highmore, the lachrymal bone, part of the nasal bone, as well as the nasal process of the frontal bone, the thin lamina of the ethmoid and, finally, the anterior and inferior walls of the frontal sinus.

On opening the nasal cavity the tissues generally involved by the neoplasm are to be removed. As a matter of fact, the whole ethmoidal labyrinth, including all the cells down to the anterior wall of the sphenoidal sinus, should be taken away, and even the apparently sound tissues thoroughly curetted. If this is done it is less likely that ramifications of the tumor may remain. The posterior wall of the maxillary and frontal sinuses, as well as the remains of the orbital walls, are removed in such a way that these cavities are converted into one common space.

This exenteration is always accompanied by profuse hemorrhage and, in addition to the ordinary means of hemostasis, it is generally necessary to

turn the patient well over on his side or on his face to prevent suffocation from bleeding into the post-nasal space.

It will thus be seen that the operation involves all the cavities as far as it is safe to carry such an operation and represents the possible maximum amount of interference in these very grave cases of malignant infection. However, it is rarely that there are any indications for evacuating the sphenoidal sinus.

The new cavity is thoroughly tamponed with simple sterilized or iodoform gauze and the ends introduced into the nasal cavity. Subsequent treatment of the parts is carried on by this route.

4 *Plastic Operation.* The musculo-cutaneous flaps from the forehead and cheek are approached by undermining and sliding them towards one

Fig. 397.

Exenteratio Orbito-sinualis. Union of Skin Flaps over the Exenterated Cavity. (Golovine.)

another. They are then sutured as shown in the figure so that the line of incisions takes the form of an ordinary H.

All the wounds generally heal by first intention and the cavity cicatrizes without further infection. Sometimes it is necessary, owing to separation of the transverse line of suture, to transplant further tissue. Probably the large cavity produced by the operation fills up with bony tissue, the skin adhering to the bone beneath As a rule the cosmetic result is good as shown, for example, in Fig. 398.

Extirpation of Cysts of the Orbit.

Perhaps the tumors most difficult of removal in their entirety are large, *thin-walled cysts* with numerous fibrous attachments to surrounding parts. These growths are easily punctured, and call for the

greatest care if one is to succeed in extirpating them. In the case of *ecchinococcus* cysts or others that answer this description, it is, on the whole, better to abandon the attempt to remove the cyst wall, but after thorough evacuation of the cyst cavity, to inject it with *a strong antiseptic.* Elschnig[32] advises a 10 per cent solution in glycerin of iodoform. Swabbing with absolute alcohol or a mixture of the same

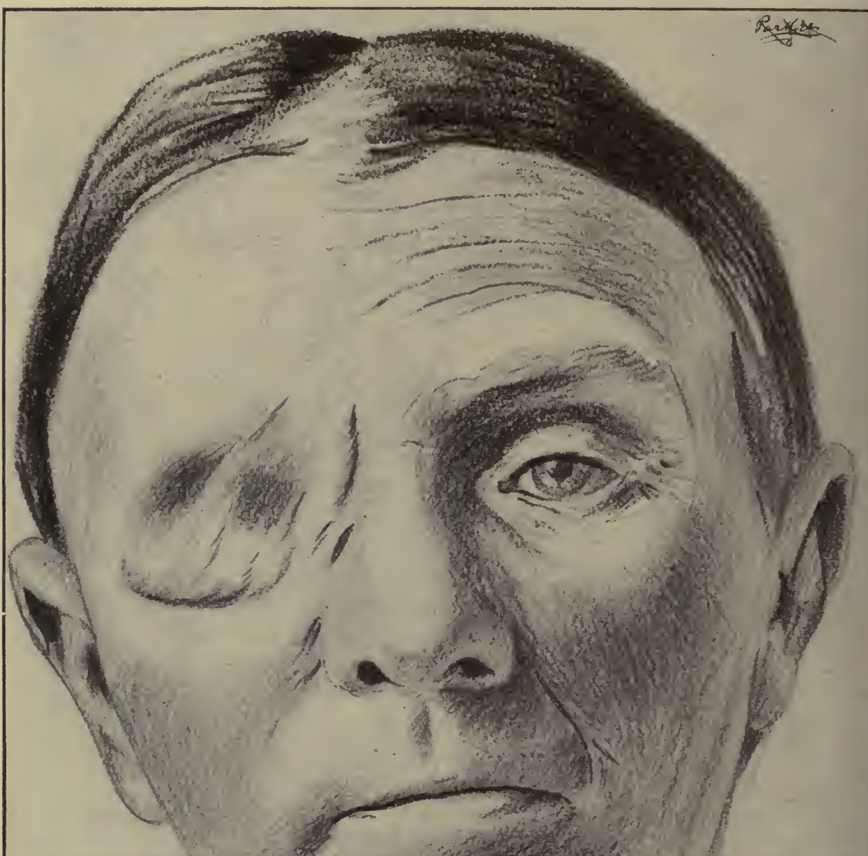

Fig. 398.
Exenteratio Orbito-sinualis. Cosmetic result. (Golovine.)

liquid with 10 per cent each of tincture of iodine and carbolic acid is effective. In either event, subsequent drainage must be provided.

As before mentioned, large, solid, as well as deeply-placed tumors of the orbit can only be properly dealt with after (temporary) resection of the temporal wall of that cavity. Only in this way can damage to the eye be avoided and a sufficiently large wound provided both

[32] Czermak and Elschnig. *Augenärtzliche Operationen*, Vol. I, p. 414.

for the intraorbital operation and for the extraction of the growth without undue dragging on the optic nerve.

The final state of the eyesight after these procedures will, of course, depend upon the degree of vision before the operation, and the damage done to the muscles, the ocular interior, the nerve supply and the tunics of the eyeball.

Tumors within the muscle-cone are chiefly *cavernous angioma* and *new growths of the optic nerve.* Intraocular neoplasms that burst through the globar wall and invade the funnel-shaped space between the straight muscles and the eyeball are malignant in character and we are interested in them, so far as operations are concerned, only from the standpoint of exenteration of the orbit (q. v.).

Angioma of the Orbit and its Treatment.

When in the anterior aspect of the orbit, this new growth may be treated by *extirpation, galvano-puncture or injections of alcohol,* the last after the manner of Gifford[33] and others. Angiomata that are confined to the lid proper (skin, conjunctiva, tarsus) may be removed in their entirety. (See Wilder's chapter, Operations on the Eyelid). If both the orbit and the lids are involved it is best to deal first with all the former only as the palpebral growth sometimes atrophies when the intraorbital portion of the tumor is extirpated. If it does not it can be dealt with as recommended under angioma of the lids. Deeper and larger angiomata external to the muscular cone must be removed by the aid of a Krönlein operation, although the Lagrange procedure may be sufficient if too much pressure upon the globe and too much injury to the nerve can be avoided. If the eye be blind or if a dangerous hemorrhage sets in, the eye may with advantage be enucleated.

The so-called "cavernous" *angiomata* generally develop within the funnel-like cavity formed by the orbital muscles. In this situation their extirpation invariably calls for removal of the eyeball; if outside the muscle-cone, an attempt may be made to exsect them either by the Krönlein method as adopted by Samelsohn,[34] or even by an incision through the fornix, as in a case described by Ahrens[35].

Arterial Ligation in Orbital Disease.

Although it is not really a part of ophthalmic surgery, *ligature of the common and internal carotid arteries* has such intimate relations with operations on the orbit that it must be mentioned here. One

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[33]Gifford. See Wood's *System of Ophthalmic Therapeutics*, page 89.

[34]Samelsohn. Eine kavernose Geschwulst der Orbita, mit volliger Schonung des Augapfels entfernt. *Berlin. Klin. Wochenschr.*, 1880, p. 13.

[35]Ahrens. Ein neuer Fall von Tumor cavernosus orbitae. *Klin. Monatsbl., f. Augenheilk.*, 1889, 27, p. 260.

or other operation is, according to Czermak[36], indicated by the following ocular conditions:

1. In the so-called *pulsating exophthalmus.* Before resorting to operation, however, *digital compression* should be tried as in some cases it cures the disease and in others increases the efficacy of the arterial ligation.

2. In *pulsating angioma,* although the prognosis in these cases is not encouraging.

3. In orbital aneurism, especially *aneurysma cirsoideum,* if the removal of the diffuse blood vessels is impracticable.

Siegrist[37] advises in the foregoing cases always to make use of digital compression (as a preliminary procedure) so as to induce collateral circulation within the areas supplied by the vessel about to be tied, as well as to accustom the heart muscle to the new circulatory conditions. It is generally a good practice, also, to do the much less serious operation of ligating the internal carotid. If this fails one may proceed to the tying of the common carotid.

4. In serious hemorrhages, unchecked by ordinary means, following operations on the orbit. This formidable situation is sometimes met either after enucleation of the eyeball, exenteration of the orbit or after severe injuries involving also the neighboring cavities where the blood pours out of the nose and mouth and it is impossible to locate the source of the bleeding.

To this category may be added some cases of intraocular hemorrhage threatening complete loss of vision.

Failure of carotid ligature to cure a pulsating orbital angioma may be due to conditions *à priori* incurable by these means.

An example of this is seen in a case recorded by Jack[38]. A female, aged 54, bumped her right temple against a door; no attention was paid to it. Two days later the writer noticed that the lid and tissues about the eye began to swell, with increasing exophthalmos of a pulsating character. The condition became rapidly worse. A pressure bandage over the carotid was of no service, and the pain became intolerable. The common carotid was then tied. The eye symptoms improved, but the general condition grew worse, and death followed four weeks later. The postmortem findings showed a sacculated aneurism of the right internal carotid artery which had burst into the cavernous sinus.

Pulsating Exophthalmus. Pulsating Angioma.

The commonest operation for all forms of this condition is *ligation of the common, internal or external carotid.* Ligation of the ar-

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[36]Czermak and Elschnig. *Augenärtzliche Operationen,* I, p. 420.

[37]Siegrist Die Gefahren der Ligatur der grossen Halsschlagadern für das Auge und das Leben des Menschen. *Archiv f. Ophthal.,* 1900, 50, p. 511.

[38]Jack. A Case of Pulsating Exophthalmos; Ligation of the Common Carotid; Death. *The Ophthalmic Record,* Oct., 1907, p. 463. See, also, Frothingham, Pulsating Tumor of the Orbit, resembling true Aneurism. *Am. Jour. of the Med. Sciences,* Vol. 73, p. 97, and the statistics furnished by the monograph of de Schweinitz and Holloway.

teries of the neck has been successful in numerous instances. For particulars of the operation see Halstead's chapter in this *System*.

Among the reported cases are two by Würdemann[39] and Bull[40].

In Würdemann's patient the condition seemed to have arisen spontaneously, a "sudden snap in her head" being felt while she was in a constrained position. This was immediately followed by dizziness and vomiting, and later the bruit, protrusion of the eye, headache and other symptoms of this condition, which had continued for one year.

Bull's patient was rendered unconscious by a blow on the head. The next morning he noticed the roaring noise, and on the second day protrusion of the eye and swelling of the lids. He was first seen a month later, when enormous distension of the retinal and conjunctival veins was a striking feature of the case. Both cases were probably typical examples of the spontaneous and traumatic forms of rupture of the carotid into the cavernous sinus, or other form of arterio-venous aneurism.

Travers was probably the first (1805) ophthalmic surgeon to bring this means of treating pulsating exophthalmus to the notice of the profession. Of the case he reported, Mackenzie[41], says:

"The bold and successful practice of Mr. Travers, who, for an aneurism by anastomosis, within the orbit, tied the common carotid artery, has been followed by Mr. Wardrop in several cases of this disease, situated externally."

"The only other mode of treatment likely to impede the progress of an anastomotic aneurism within the orbit, is diminution of the force of the circulation through the tumor, by applying a ligature on the common carotid artery. We owe the first proof of the efficacy of this plan, not only in preventing the increase, but even in effecting the cure of this disease, to Mr. Travers."

Probably the conclusion of Golovine[42], who has had considerable experience in these cases, may be given, particularly as regards their operative treatment. He believes that the combination of ligation of the common carotid with ligature of the orbital vessels is the last word in the treatment of the most pronounced form of pulsating exophthalmus.

He sums up the arguments of his paper thus: 1. The operation suitable for a given instance should depend upon the peculiarities—especially the symptoms—of the case. 2. When the cerebral signs and symptoms are prominent (vertigo, noises in the head, pulsation) ligature of the carotid should form at least one part of the procedure. 3. If the symptoms are confined to the orbit then tying the orbital vessels will generally bring about a cure. 4. In ligation of the superior ophthalmic vein it often suffices to reach it by an incision beneath the eyebrow but in other instances a Krönlein operation is required. 5. In failure of carotid ligature or tying the ophthalmic vein to cure the case, or when a recurrence of the disease is to be treated temporary restriction of the external wall of the orbit should be employed. 6. Ligature of the remaining common carotid (in failure or recurrence) is not to be recommended owing to [the danger of death; see Howard Hansell's[43] report. W.] the serious disturbance of the cerebral circulation. 7. Some form of resection of the temporal wall must be employed if, in addition to the pulsating exophthalmus, there is the slightest suspicion of orbital tumor.

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[39]Würdemann. Pulsating Exophthalmus, *Annals of Ophthal.*, April, 1903.

[40]Bull. Pulsating Traumatic Exophthalmus, *Trans. Am. Oph. Soc.*, 1903.

[41]Mackenzie. *A Practical Treatise on The Diseases of the Eye.* 1830. pp. 160 and 291.

[42]Golovine. Die operative Behandlung des pulsirenden Exophthalmus. *Zeitschr. f. Augenheilk.*, Vol. 4, 1900, p. 199.

[43]Hansell. *Jour. Am. Med. Ass.*, 44, 1905, p. 536.

Gifford's[44] further experience leads him to welcome any effective method of dealing with these cases which is free from the dangers attending ligation of the carotids. In at least a respectable proportion of cases ligation of the ophthalmic vein is effective; Gifford thinks that when decided indications of a distended vein can be felt in the orbit this operation will eventually be the operation of choice. Whether additional observation will show that it is entirely free from danger remains to be determined. The alarming symptoms which followed the operation in the cases of Lasarew, Sattler and in the writer's own case, both after the first ligation of a superficial vein and later on, coincident with the spontaneous thrombosis of the orbital vessels, indicate that the danger of fatal thrombosis of the brain sinuses cannot be absolutely denied. No fatal case has yet occurred, but in recommending the operation the possibility of such an event should not be lost sight of.

Although ligature of the common or internal carotid is the usual method employed in the attempt to relieve the various forms of pulsating exophthalmus, yet ligation of almost all the large vessels that supply the arterial or venous aneurism has been at various times recommended. Noyes[45] cured a case by tying the angular artery and the inferior orbital vein. Golovine[46] was the first (p. c.)—in 1887—to control this serious condition by the ligation and excision of the superior ophthalmic vein.

Beauvois [Traitement de L'Exopthalmie Pulsatile par la Méthode Lancereaux-Paulesco. *Recueil D'Ophtalm.*, June, 1907] highly recommends (and has reported two successful cases in which he used *gelatine-serum injections* in this disease, after the manner of Lancereaux and Paulesco.

These surgeons presented their report to the French Academy of Medicine in June, 1897. The solution which they made use of is manufactured as follows:

White gelatine ....4 to 5 grammes.
7 per cent solution of sodium chloride, 200 C. C.

The solution is sterilized in a water bath and its temperature raised to 120 degrees C. It is desirable to prepare in advance a number of bottles containing the sterilized fluid, which should be kept at a temperature of 38 degrees so as not to permit the gelatine to solidify before using. When required for injection beneath the skin it is drawn into a syringe capable of holding 500 cc. and the whole sterilized at 120° C.,

[44]Gifford. Pulsating Exophthalmos Treated by Excision of a Dilated Orbital Vein. *Ophthalmology*, October, 1907, p. 20.

[45]Noyes. Pulsating Exophthalmos. *Trans. American Oph. Soc.*, 1881, p. 308.

[46]Golovine. Orbitale Operationen bei pulsirindem, Exophthalmus, *Zeitschr. f. Augenheilk.*, Vol. 4, 1900, p. 187.

or by simply keeping it in boiling water for a quarter of an hour. The field of operation, preferably the buttocks, should be very carefully sterilized. The needle of the syringe is then deeply plunged into the tissues so that its point reaches the underlying aponeurosis. The injection should not be made too rapidly, but should be completed at the end of a quarter of an hour.

Carried out in this way the injection, contrary to what might be expected, is not painful. Absorption takes place rapidly and is not followed by any local or general irritation. The effect, also, is marked; the patient should be kept on his back and the aneurism should not be touched after the injection. All sudden movements on the part of the patient should be discouraged.

The injection should be repeated every six to eight days until the obliteration of the sac takes place.

When it is important to establish a collateral circulation it is better to employ solutions still weaker, namely, one to one-half per cent, and to permit an interval of from eight to ten days to elapse between the injections.

Lancereaux insists that the quality of the gelatine shall be above suspicion. He uses that known in commerce under the name of gélatine blanc-mange which makes a bluish solution. Beauvois remarks that Lancereaux has never had a serious accident following the hundreds of injections that his pupils and he have given in the treatment of aneurism.

Harold Gifford's[47] interesting case leads us to believe, with de Schweinitz and him, that when a cautious exploration of the affected orbital vessels results in the discovery of a specially enlarged vessel it should be selected for ligation. This observation greatly simplifies the operative treatment of these serious cases; and indeed, ligation of the most prominent orbital vessel or vessels might be regarded as the first care of the surgeon, and should be practised before more formidable methods are considered.

Taylor[48] reports a case in which the common carotid was tied with success. After four years there had been no recurrence of the disease. Brewerton points out that ligation of the internal carotid, instead of the common carotid as usually advised, is less frequently followed by cerebral symptoms and, in his opinion, is more likely to be followed by cure.

In a case due to trauma R. Sattler[49] dissected out the aneurysmal sac in the orbit, ligated each end of it and excised the whole mass. Complete relief followed. As the tumor was favorably situated it was not necessary to do a Krönlein operation. In order to prevent too free hemorrhage a ligature was passed around the common carotid.

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[47]Gifford. Pulsating Exophthalmus from Aneurismal Varix in the Neck. *Ophthalmic Record*, April, 1899, p. 174.

[48]Taylor. Pulsating Exophthalmos Cured by Ligature of the Common Carotid. *Trans, Oph. Soc. U. K.*, Vol. 25, 1905, p. 177.

[49]Sattler. Ueber ein neues Verfahren bei der Behandlung des pulsierenden Exophthalmus. *Klin. Monatsbl. f. Augenheilk.*, July, 1905, p. 1.

de Schweinitz and Holloway[50] report a case of orbital aneurism in which the right common carotid was ligated for the relief of pulsating exophthalmos April, 1900, and the left internal carotid in February, 1901. In both these operations there was temporary improvement. Later the symptoms returned and nearly three years after the last operation the patient, while playing football, received a blow on the head and immediately afterwards noticed cessation of the bruit.

These authors have collected and analyzed three hundred and thirteen undoubted cases of the disease and have considered, amongst other things, the treatment, which they have divided into ligation of the larger blood vessels of the neck; operations on the orbit; compression of the common carotid; direct compression of the venous swelling of the eyelids and angle of the orbit; gelatine injections; the administration of drugs and rest in the recumbent posture. They have reached the following conclusions with regard to the operative treatment: "In the presence of true pulsating exophthalmos surgical procedures should take precedence, and time is probably wasted by an attempt to cure the lesion by the administration of drugs, although injections of serum gelatin may be considered if the presence of an aneurism of the ophthalmic artery is known to exist.

Of the ligations of the neck arteries the best results are liable to follow ligature of a common carotid, as the contention that ligature of the external and internal carotid is the preferable procedure is not borne out by the statistics. If there is failure to relieve or cure the symptoms by the ligature of one carotid before the second carotid is tied, the orbital operation of dissecting out and tying the distended vein should be tried.

In the presence of a distinct venous swelling in the orbit, with evident distension of the angular or superior ophthalmic vein, the operation of choice should be isolation, ligature, and resection of this venous channel, inasmuch as thus far, although the operations are few in number, they have been uniformly successful."

The *treatment of orbital angioma by galvanocautery* is not to be recommended except in those rare cases where other procedures are useless, such as, for example, deep-seated angioma whose extirpation is attended with difficulty.

Encephalocele and its Surgical Treatment.

Berlin[51] in 1880, placed these tumors of the orbit among inoperable growths, but improvement in the technique, and particularly the observance of aseptic precautions, have brought surgical intervention in their behalf within the province of the operator. We are mostly interested in sincipital tumors and the removal of the whole sac with its contents has been recommended by Bergmann.[52]

Naso-orbital encephaloceles, including encephalocele and hydrencephalocele, are the commonest variety with which the ophthalmologist has to deal, although the prognosis in both instances is by no means encouraging.

In dealing with small encephaloceles an incision is made through the skin and muscular coverings at the most prominent part of the

[50] de Schweinitz and Holloway. Concerning Pulsating Exophthalmos. *Trans. Coll. Phys. of Phila.*, 1907. See also their monograph, *Pulsating Exophthalmos.* Philadelphia and London, 1908.

[51] Berlin. *Graefe-Saemisch Handbuch der ges. Augenheilk.*, 1st Edition. Tumors of the orbit.

[52] Bergmann. *Die chirurgische Behandlung von Hirnkrankheiten*, 1889, p. 11.

tumor, or if that is undesirable owing to degenerative changes, the opening may be made elsewhere. The sac is generally of a transparent scar-like quality and is often the seat of vascular changes, like a telangiectatic angioma. The meningeal coverings are wanting in some cases so that the tumor is in direct contact with the brain substances.

The encephalocele is, as a rule, easily separated from the surrounding tissues back to its pedicle which, after ligation with catgut, is cut through close to the bony foramen, the tumor removed, the skin wound sutured and an antiseptic dressing applied.

Large-sized encephaloceles require an extensive procedure. Two semi-circular skin flaps are fashioned at the base of the tumor to cover the defect caused by its removal. These are turned back, the pedicle exposed and cut off 2 or 3 cm. from the bone. The borders of the sac are stitched to the opening in the cranial cavity and it is often necessary to reinforce this covering by a second one. In this operation protruding brain matter involved in the tumor should be removed with it.[53]

Elschnig[54] remarks that the operation is contra-indicated in abnormally small skulls—"frog-head:" in marked hydrocephalus, and in complications with other malformations that threaten the life of the child.

Operations on the Orbital Walls.

Although it may with some truth be asserted that operative procedures affecting the bony walls of the orbit are in some cases more properly within the province of the rhinologist or the general surgeon, because in these instances the osseous structures are involved secondarily by growths or disease *originating outside* the orbital cavity, yet the ophthalmic surgeon should be prepared to deal with this contingency as *one of that series of surgical interventions that may be carried out by any one of the three.* In other words, orbital surgery is sometimes neutral ground that touches or includes several specialties, is common to them all and that may with equal propriety be occupied by all. In any event, whether the ophthalmologist elects to do the work himself or calls in his brother rhinologist or general surgeon, he should at least be acquainted with the technique of the proposed operation. For any or all these reasons the whole range of orbital operations, as well as their preliminary and after treatment, has been rather extensively treated in these volumes.

It is premised that all the operative measures about to be described are subject to the ordinary surgical rules of asepsis, anesthesia,

[53]For further particulars see Bergmann and Bruns, *Handbuch der prakt. Chirurgie*, 1907, 1, p. 152.
[54]Czermak and Elschnig. *Augenärtzliche Operationen*, I., p. 421.

hemostasis and dressing, and that the preliminary preparation and after treatment must be carefully planned and carried out as in any major operation upon similar tissues elsewhere in the body. These important matters are not only fully discussed elsewhere but special reference to them will be made in connection with individual operations whenever occasion calls for it.

Operations for the Relief of Caries and Necrosis of the Orbital Margins or Walls.

Both these processes affect most frequently the lower-outer margin of the orbit and are generally accompanied by a fistula surrounded by unhealthy or granulating tissue.

The fistula should be *thoroughly exposed throughout its whole length,* the incision extending beyond the external skin, the edges of the wound separated by hooks and the diseased bone scraped with a sharp spoon. If the use of the raspatorium is not sufficient to remove the carious tissues, the hammer and chisel should be employed until only healthy bone remains. One should bear in mind the cause of the local disease. It is sometimes due to syphilis, for example, and the treatment of such a case is, of course, obvious. In any event, the general conduct of these cases is always important.

The *local treatment* of the surgical wound is that of bone wounds generally. Iodoform gauze dressings after the careful readjustment of the soft parts by means of sutures are the main indications. The depressed scar that always follows the healing of the operative wound may be dealt with by various operations—osteoplastic and other—that are fully described in these volumes. Perhaps the following method of meeting the disfigurement is the most effective.

Mosetig's Method of Preventing Deformity After Orbital Exenteration and Bone Curetting.

Instead of waiting until the wound has healed and then dealing with the defect in the tissues by a plastic operation an attempt to supply a pad of "artificial bone" may be made. Mosetig[55] proposes to accomplish this end by treating the freshly made wound as follows: After the primary procedure is completed, the bone wound smooth and the bleeding entirely stopped, the field of operation is irrigated with a 1 per cent. formalin solution. As soon as the bone surface is quite dry (and this result may be hastened by holding near it the Paquelin or electrocautery), the wound is filled with the following mixture *(Iodoformknochenplombe),* sterilized in a water bath and then sufficiently cooled:

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[55]Mosetig. Erfahrungen mit der Iodoformknochenplombe. *Deutsche Zeitschr. für Chirurgie,* 1904, 71, p. 419.

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Iodoform	60.0
Spermaceti	..
Olive oil, of each	40.0

The periosteal wound is closed with catgut, the skin incision with silk sutures. The curetted fistulous canal in the soft parts (or orbital cavity) is filled with strands of iodoform gauze. In the absence of a fistula, this drainage is inserted at the lowest angle of the wound. An iodoform dressing is now applied and renewed at each dressing. As long as there is any secretion from the wound or while particles of the spermaceti compound come away, the artificial drainage must be continued, after which the iodoform threads may be removed. On the eighth day the silk stitches can be taken out.

Resection of a Portion of the Orbital Margin.

The surgeon is generally required to perform this operation in depressed and healed or partially healed fractures of the orbital margin with deformity. This is especially true when a neighboring cavity is encroached upon or where ectropion, entropion or lagophthalmus is the result of the injury. The depressed bone should be exposed by dissecting and carefully freed from its bony attachments—using for the latter purpose bone scissors, the electric drill and saws. These instruments will generally be found more satisfactory than the hammer and chisel of the older surgery, since splintering of the osseous structures and injury to the soft tissues can be more readily avoided.

Once separated from its adhesions the bony section is lifted from its bed and secured in its normal position by periosteal stitches or metal sutures.

If the depression is considerable the orbital margin may be restored by the method of Gayet[56], who with a dentist's drill makes a row of perforations beneath the affected bone, afterwards joining them with the chisel or saw; or, with the electromotor circular saw alone, thus freeing the bone from its abnormal position. It is afterwards sutured in place by means of a metal plate.

It is quite evident that the technique of these operations will vary greatly in individual cases. In every instance the position of the soft parts—especially of the nerves and blood vessels—must be duly considered. Supplementary plastic operations on the soft tissues may also be required to complete the cure.

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[56] Gayet. De la restauration osseuse du rebord de l'orbite. *Archiv. d'Ophtal.* 1892, p. 193.

Resection of Part of the Orbital Walls. [57]

In the majority of cases this procedure is demanded as part of an operation for the *removal of tumors* or in conjunction with operations on the neighboring cavities. Less frequently it is employed in the *extraction of foreign bodies, including splintered bone,* that have become firmly imbedded in the orbital framework, producing irritation or inflammatory symptoms.

The instruments employed in *orbital osteotomy* (q. v.) will also be found useful in resection—especially the various drills and saws (q. v.) that are generally a part of the dentist's armamentarium—when used with care and after a study of the parts involved are more effective and no more dangerous than the chisel and hammer. Bone scissors (q. v.) of various sizes and patterns will also be found useful.

The *operation* itself consists of cutting down to and exposing the region of the proposed resection, avoiding as far as possible important structures and elevating only the periosteum covering the bone parts to be removed. The bloodvessels may be cut in almost any orbital region as their anastomosis is abundant, but the nerves, the muscles with their attachments and the body of the globe itself must be sedulously avoided.

One should particularly bear in mind, at the base of the orbit, the nervous supply to the orbicularis (fibres of the facial), the frontalis, the supraorbital and the infraorbital nerves. In the upper aspect of the orbit lies the lachrymal gland with its various coverings, at the middle-inner aspect the pulley of the superior oblique muscle and on the upper maxillary the origin of the inferior oblique. Still further behind and at the orbital apex, the optic nerve, the nerves that pass through both the superior and inferior orbital foramina, as well as the origin and the common tendon of the straight muscles that have their attachment about the optic foramen.

Especial care should be observed in doing a *resection along the lateral walls of the orbit* lest the fibres of the facial that supply motor energy to the orbicularis be divided. Instead of making a preliminary incision through *all* the soft parts it is better, when feasible, to reach the bony structures by way of the bottom of the conjunctival sac—the folds of transmission. That the field of operation may be sufficiently large the external canthus may be divided the incision extended, above or below, to the sulci and then to the periosteal surface as required. The lids should now be widely separated by speculum or elevators in the hands of the assistant and the bleeding stopped so that the bared orbital wall may be sufficiently exposed.

Incisions through the upper sulcus for the purpose of reaching the upper aspect of the cavity are almost certain to involve the tendon of the levator palpebræ and the ducts of the lachrymal gland and should, accordingly, be avoided. It is far better to expose the upper orbital margin by means of a skin incision confined to the central portion of the cavity as the only tissue of importance there is the nerve

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[57]The Editor is indebted to Czermak's *Augenärtzliche Operationen*, Vol. I. p. 383, et seq., for a number of valuable suggestions that are introduced into this section of the chapter.

fibres supplied to the orbicularis which, if cut, do not in this region materially interfere with the closing of the lids.

One must not, however, extend the incision *too far inwards* as that will involve the supraorbital and frontal nerves with their accompanying arteries. On the other hand, especially when these tissues pass through a foramen instead of a shallow notch, both nerves and vessels may be carefully isolated. The primary incision is made at the lower border of the eyebrow, through skin and muscle, the periosteum is exposed, incised, raised with the periosteal elevator, when the operation is completed with chisel, hammer, scissors and raspatorium and the unwounded organs held to one side until the resection is finished, when they are returned and, if necessary, stitched in their normal position.

Having taken care of the nerves and vessels as just described the operator can then undermine them while his assistant, with proper hooks or a specially devised speculum, exposes the whole length of the upper orbital wall.

The *pulley of the superior oblique* may be involved in a resection of the inner-upper wall of the orbit, but so long as it is not separated from the periosteal covering that binds it to the bone it may be chiseled out with its osseous attachment and no permanent damage done. In other words, *the soft parts* of the trochlea should be disturbed as little as possible.

Resection of the inner wall of the orbit may involve the lachrymal sac and check ligaments of the internal rectus. It is, consequently, better to carry the *primary incision through the soft parts along the upper-inner* half of the orbital margin and to raise the periosteum through this wound. This procedure will involve the angular artery and external nasal nerve, but division of these structures is not a serious matter. It must again be remembered that any considerable enlargement of the wound upwards and outwards may injure the trochlea and the frontal nerve.

Resection at the lower border of the orbit may involve the origin of the inferior oblique, the infraorbital nerve and some tendinous fibres of the oblique. If the resection involves any considerable portion of the inferior orbital wall the whole canal with the nerve, as well as a thin lamella of bone with the attached muscular fibres can be chiseled out and drawn to one side with a hook or suture until the completion of the operation.

Resection of the entire outer or entire lower wall of the orbit requires a much more extensive operation. It involves, among other considerations, the separation of the malar bone from the superior maxillary and is usually regarded as a part of general surgery. It must be borne in mind that *any extensive resection of the inner-upper wall of the orbit will expose the frontal sinus and the inner wall of the ethmoid cells, while a similar operation on the lower wall will open the maxillary sinus and the nasal cavity.*

Removal of Bony Tumors Involving the Orbital Walls.

At the outset it should be decided whether with the aid of Krönlein's operation (q. v.) with or without exsection of any part of the orbital wall (q v.), opening of one or more neighboring cavities, etc., a useful, normal appearing or movable eyeball can be preserved. If such is the case, the appropriate procedure is indicated and should be resorted to as early as possible. If, however, neither a functionating nor a sightly eye can be preserved, it is better at once to clean out the entire orbit by means of a simple exenteration (q. v.) and at the same time remove a growth that threatens the comfort and life of the patient.

One of the principal dangers attendant upon the removal of *deep-seated exostoses and osteomata,* even when these tumors are circumscribed in character, is the subsequent infection of the cranial

cavity. This serious complication is all the more imminent if the growth affects the inner-upper part of the orbit or encroaches on its upper wall alone. Such tumors often originate in the frontal sinus or that cavity must be opened in their removal. Close at hand is the floor of the cranial cavity and its covering may be directly or indirectly involved in the operations required for the removal of these tumors. Indeed, Berlin[58], writing in 1880, opposed the removal of these bony growths from the orbit because of the high mortality—25 per cent from purulent meningitis. In later years, however, Birch-Hirschfeld[59] gives a more encouraging prognosis, due not merely to improvement in operative technique and the employment of careful asepis, but especially to the employment in diagnosis of the X-rays and transillumination. Now, the surgeon can decide more effectively than ever before, the *location, size* and *origin* of the tumor he is about to deal with and is better able to select his cases.

Birch-Hirschfeld finds that of 214 cases of osseous tumor of the orbit described in literature 30 were *external exostoses*, 5 were *hyperostoses* and the remainder, 179, *osteomata*.

Of the exostoses 18 were operated on without a death; of the hyperostoses two operations and no death; of the osteomata all sprang from one or more neighboring cavities. Of these the frontal sinus furnished 115, the ethmoid cells 52, the sphenoidal sinus 10 and the maxillary sinus 6.

The mortality in the cases not operated on was decidedly greater than when operation was resorted to. Comparing those cases reported since the introduction of antiseptics he finds in the frontal sinus osteomata operated on a mortality of 13.6 per cent. as opposed to 48.2 per cent. in those left to themselves; in the ethmoidal tumors operated on there was a mortality of 12.7 per cent.; not operated on 80 per cent. In the sphenoidal cases 33 per cent. died after operation; in those not interfered with 100 per cent

The clinical histories and *details of operation in two cases of osteoma of the orbit* successfully removed by operation without involvement of the eyeball are given at length by Arnold Knapp.[60] In the first case the tumor was located attached by a small pedicle at the upper-inner angle of the orbit, displacing the eye downwards and outwards. After operation the wound was closed and healed by primary union. In the second case the mass occupied the upper half of the orbit, displacing the eye forward and downward on the cheek. It had a broad attachment to the entire upper bony wall. The origin of the growth was from the superior wall of the frontal sinus and it had penetrated the inferior wall and extended into the orbit. The wound was left open and a gauze drain inserted. Recovery was rapid and the wound closed in eleven days.

Extirpation of Exostoses and Osteomata.

The prognosis in the growths will, as before stated, depend upon their size, situation and the locality from which they spring. It may be broadly declared that from the operative standpoint they belong to one of two classes. Either the tumor arises from and is attached to the anterior lamella of bone forming the orbital wall and in its future

[58]Berlin. *Handbuch der ges. Augenheilk.* First Edition, Vol. VI., p. 729.

[59]Birch-Hirschfeld. Zur Kentniss der Osteome der Orbita. *Bericht der Ophthalmolog. Congress*, Heidelberg, 34, 1907.

[60]Knapp. Two Cases of Osteoma of the Orbit Successfully Treated by Operation. *Archives of Ophthalmology*, July, 1906, p. 353.

growth is confined to the orbit, or it is a growth from a neighboring cavity, presses against the orbital wall, pushes it towards the orbital axis and finally breaks through into the orbit itself.

Exostoses that spring from the inner table can generally be removed with the hammer and chisel at their attachment or a piece of bone including the point of union, can be exsected.

Osteomata of the orbit, especially of the *ivory* variety generally require additional means of enucleation. The electric (dentist's) drill, bone scissors, elevators, and saws may have to be called into play before these refractory growths can be entirely extirpated.

The subject of removing tumors of extraorbital origin comes naturally under the chapters in this *System* by Brawley and Halstead. It may here suffice to say regarding orbital tumors originating in the frontal sinus (constituting three-fourths of these growths) that Birch-Hirschfeld favors their *total extirpation, when any operation is done* because his statistics show that the mortality in the first instance was only 8.9 per cent. as compared with 34.6 per cent. in the latter case.

Krönlein's Operation.

In 1887 Krönlein[61] applied to the removal of a tumor from the orbit the manœuvre first suggested by Wagner[62] for the extraction of foreign bodies deeply lodged in that cavity—the exposure of its contents by the temporary resection of a part of the external wall.

This procedure consists in making a crescentic incision through the skin at the external margin, cutting through and stripping the periosteum from the external wall of the orbit and then *sawing or chiseling from this wall a wedge-shaped piece of bone whose apex corresponds to the sphenomaxillary or inferior orbital fissure.* The loosened osseous segment may now be turned out towards the temple, exposing for operative purposes the whole length of the orbital cavity with its contents. After the necessary surgical intervention, the bony wedge is replaced and the edges of the wound in the soft parts brought together by sutures.

For this operation a number of instruments are required besides the ordinary ones for dividing the tissues, retractors, raspatoria, tenacula, osteotome, mallet and chisels, dental engine with its usual saws, strong bone and tissue forceps, suture material, stout needles and needle-holder, and spatulæ.

After the field of operation has been carefully prepared, the hair

[61]Krönlein. Zur Pathologie und operativ. Behandlung der Dermoidzysten der Orbita. *Beiträge zur Klin. Chirurg.* IV., 1, 1887.

[62]Wagner. Die Behandlung der Komplizierten Schädelfracturen. *Sammlung Klin. Vorträge*, No. 271, p. 86, 1886.

Fig. 399.
Krönlein Operation. Incision through the Soft Parts.

about the face and temple shaved, etc., the patient is placed under the proper general anesthetic.

The first step is the incision of the soft parts, made in the manner shown by the accompanying figure.

It describes an arc of a circle with the convexity towards the external angle, beginning about half an inch above the angular process of the frontal bone and terminating about the middle of the zygoma. The upper-middle part of the incision follows the outer margin of the orbit and involves only the skin, fascia and part of the muscle. In the middle and lower part the incision should reach the bone. The whole incision ought, in adults, to be about 8 cm. long. The periosteum in the deeper portions of the incision along the outer margin of the orbit should be thoroughly incised, raised and loosened by means of an elevator. Then, working over the margin into the orbit towards its apex, the periosteal lining is carefully separated until the spheno-maxillary fissure is reached and the bone freely exposed. An assistant meantime holds the orbital contents away from the operative field by means of a spatula. The soft parts should not be dissected from the external surface of the proposed wedge. It will be noted that the apex of the osseous cut (see Figure) lies about the middle of the fissure.

The *cutting of the bone* may be done by a small hammer and flat chisels but the dental engine, provided with both circular and band saws, is preferable as it is so much more easily worked. Moreover, the saw makes a neater cut and does not splinter the bone or necessitate chipping of the osseous structures.

Whatever instruments are employed it must be remembered that the initial bone incision runs through the base of the external angular process of the frontal while the second part of it extends downwards and backwards (mostly parallel to the orbitomalar suture) to the centre of the spheno-maxillary fissure, as shown in the figure. To join this and form the wedge pictured in the illustration, a second cut, beginning about 3 cm. below the first, is directed through the base of the orbital process of the malar bone to the anterior end of the fissure. A further extension of this cut, to meet the first and form the apex of the operative wound, is made with stout, blunt scissors.

In this way is dislodged a triangular piece of bone measuring about 3.5 cm. in length and 3 cm. in width, composed of practically the whole of the external orbital margin and that portion of the external wall whose outer surface forms part of the temporal fossa. By grasping it with forceps and moving it gently back and forth it may be further loosened from its attachments and with a resection hook turned outwards on the temple.

The lateral aspect of the orbital cavity to its apex and to a large extent above and below is now exposed to view. Growths, foreign bodies, etc., can be readily examined and removed with the least damage to the important organs that surround them. For this purpose the periosteum should be cut through, on either the upper or lower border of the external rectus muscle, with a pair of blunt scissors and the globe drawn forward and towards the median line as much as possible. If the tumor lies outside of the muscle cone it can easily be enucleated, but if inside the muscles or well behind the eyeball one or more of the straight muscles, generally the externus, must be drawn to one side by hooks held by an assistant. If this does not sufficiently expose the field of operation, the external rectus should be cut through behind the check ligaments, catgut sutures having been passed through each of the cut ends so that they may be reunited after the operation.

When the operation is concluded the cut muscle ends must be rejoined and the bony pyramid restored to its normal position. Drawing the latter gently forward at first will assist in "settling" it where it belongs. The soft parts should be carefully stitched, using catgut for the

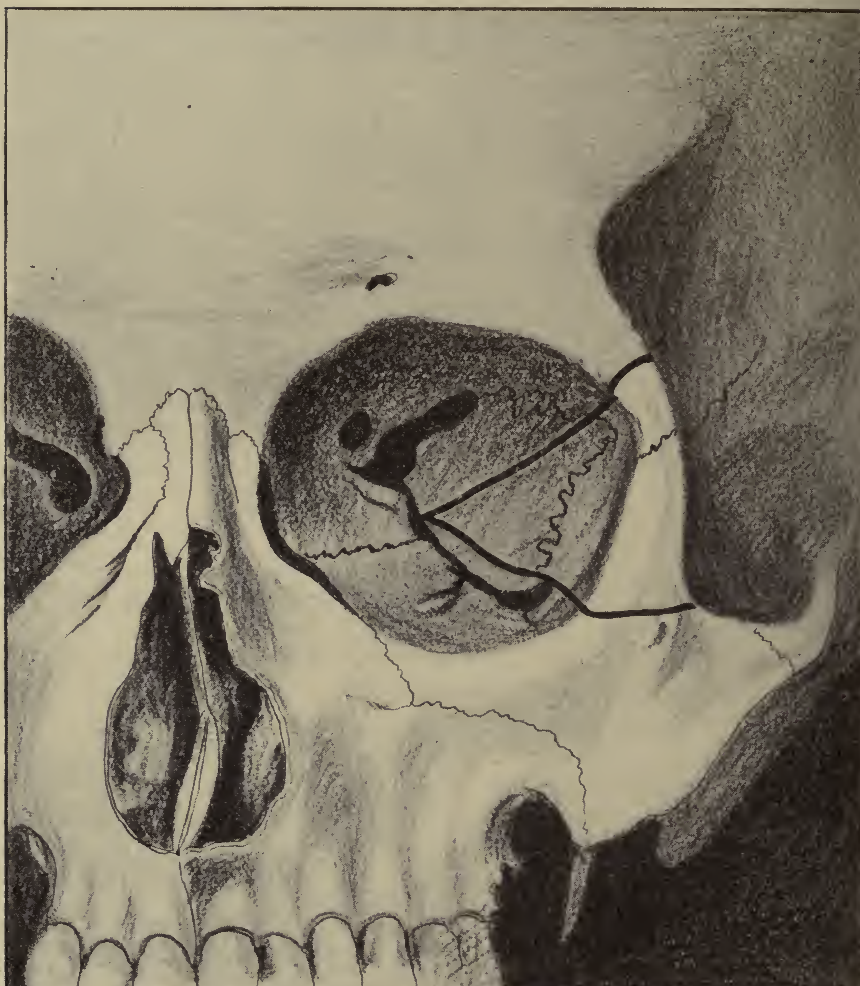

Fig. 400.
Krönlein Operation. Incisions through the Bones.

periosteal wound. An iodoform gauze drain should be laid in the most dependent part of the skin wound. The lower conjunctival sac should be filled with a 10 per cent orthoform salve and the lids held together with plaster. Axenfeld advises a provisional tarsorrhaphy instead of adhesive strips. Over all dry iodoform gauze and a light bandage.

If there be no rise of temperature, little local swelling and not much discharge—and *there is generally none of these complications if the operation is properly performed with due aseptic precautions*—the dressings need not be disturbed for three days. In the average case it is well to change the drain on the second day and to remove the superficial stitches—if these are not of absorbable gut—on the fifth or sixth day.

Czermak's Osteoplastic Resection of the External Orbital Wall.

Czermak[63] has considerably modified the original Krönlein procedure so as to give more room for intraorbital operations. He would not discard the Krönlein procedure but reserves his own operation (1) for the removal of small tumors occupying the extreme apex of the orbital pyramid, (2) for tumors lying beneath the globe and reaching well forward and (3) for such growths as lie on the nasal side of the eyeball, in which case the eyeball would have to be drawn well outwards to permit of its removal from the front. His incisions compared with those of Krönlein may be traced in Fig. 401.

It will thus be seen that in this operation the body of the malar bone, as well as the orbital process is removed, i. e., most of the orbital floor. He uses for the purpose a small chain saw worked from behind forwards with a to-and-fro motion.

There are several other modifications of the Krönlein operation, some of them desirable, perhaps, in particular instances, but on the whole the original method holds its own as a useful and comparatively safe operation.

Parinaud and Roche,[64] to avoid the rather marked cicatrix left by the usual operation recommend a *square flap* of the soft parts, reaching from the temple to the margin of the orbit. The incision commences at the outer end of the eyebrow, runs horizontally backwards about 5 cm., then vertically downwards 5 cm., and finally 5 cm. horizontally forwards. The rectangle of skin thus enclosed is loosened up to its base and turned over forwards. The remainder of the operation is the usual Krönlein procedure. Some observers believe that the post-operative healing is more uncertain in this than in the case of the Krönlein method.

For several excellent and well illustrated papers on this subject we are indebted to Angelucci and S. Calderaro.[65]

Angelucci[66] advises that the incision (4 cm. long) through the soft parts begin at the external angle of the orbit and run vertically to the base of

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[63]Czermak. Zur osteoplastischen Resektion der äusseren Augenhöhlenwand. *Deutsch. med. Wochenshr.* No. 39, 40, 1905. Also *Augenärztliche Operationen*, 2nd Ed., Vol. I, p. 402.

[64]Parinaud. Angio-Fibrome de L'Orbite, Modification au Procedé de Krönlein. *Annales d'oculistique*, Vol. 126, 1901, p. 241.

[65]Calderaro. Un Processo Operativo per lo Svoutamento Dell'Infundibolo Orbitario con Conservazione del Globo. *Lavori di Clinica e patol. oculistica*, Vol. IV., 1909. See, also, Ein Operationsverfahren zur Ausräumung des Infundibulum Orbitae mit Erhaltung des Augapfels. *Klin. Monatsbl. f. Augenheilk.*, May-June, 1910, p. 581.

[66]Angelucci. *Atti dell' Congresso Italiano d' Oftamologia*, 1905. See, also Sulla resezione permanente e temporanea dell' orbita nella estirpazione dei tumori retro-bulbari. *Gazzetta Internazionale di Medicina*, Anno VIII., October, 1905.

the orbital process of the malar bone. From the lower end of this he makes another about 20 mm. along the upper border of the zygoma. With a saw he then divides the orbital process of the malar to a depth of 6 mm. below; above, he follows the frontal-malar suture in the same way for 3 mm. He then raises the periosteum from the entire internal surface of the orbit and grasping the bone included in the incisions just mentioned *dislocates it outwards*, producing a fracture along the sphenoidomalar suture. Care is exercised not to use too much force and to supplement the saw, when needed, with bone forceps.

It will suffice, perhaps, simply to mention certain other modifications of technique in the Krönlein method, all of which may be more thoroughly studied in the original monographs. Among these are the *malar orbitomy* of Rollet,[67] the *temporary resection of the superior orbital margin* of Cahen and Franke[68] and the operation, also made along the eyebrow, of Pihl[69], the two last named intended especially to reach tumors lying above and to the nasal side of the globe.

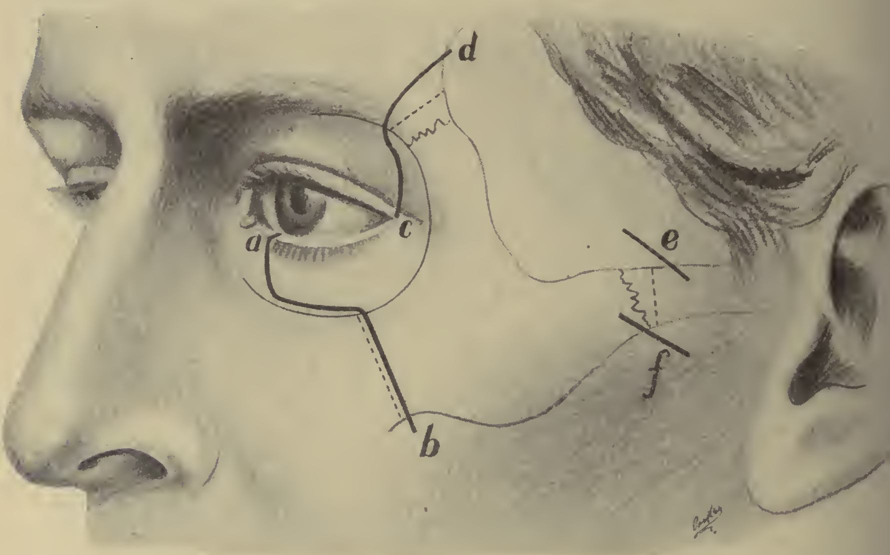

Fig. 401.
Czermak's Osteoplastic Resection of the External Orbital Wall.
a, b, c, d, e, f, the incisions through the soft parts. The dotted lines indicate the deviation of the bone sections from those of the usual Krönlein operation. (After Czermak.)

Value of and Indications for the Temporary Resection of the External Orbital Wall.

Almost any area or point within the orbit, however deep or covered by the orbital contents it may be, is accessible to operative measures

[67]Rollet. Exophthalmie guérie par orbititomie malaire. *Annal. d'Oculist.* Vol. 126, p. 370.

[68]Franke, Eine neue Methode der osteoplastischen Freilegung der Orbita. *Deutsche Zeitschr. f. Chirurgie*, Bd. 59, Heft 1 and 2.

[69]Pihl. Eine Abänderung des Hautschnittes bei der temporären Resektion der äusseren Orbitalwand nach Krönlein, *Centralbl. f. pkt. Augenheilk.*, June, 1905, p. 171.

after one or other of the resections just described. Necrotic bone is otherwise inaccessible regions can be scraped or chiseled without danger, not excepting the floor of the cranial cavity. One should, however, exercise especial care in avoiding the lachrymal fossa with its glands, and the attachments of the muscles to the bony walls. Injury to the former may produce a chronic fistula and to the latter may interfere with the normal excursions of the eyeball.

As before mentioned, the operative wounds in these operations generally heal kindly, quickly and without complications.

Czermak and Elschinig[70] sum up the *indications for resection of the external wall of the orbit as follows:*

1. In operations requiring operations on the lateral wall or posterior part of the eyeball; for example, in L. Müller's exsection of the scleral wall in *separation of the retina* (q. v.), the removal of subretinal cysticercus in the macular region, etc.

2. For extirpation of extensive tumors of the optic nerve, with retention of the globe.

3. For removal of orbital tumors in general, of cysts (dermoids, cysticerci), of osteophytes that lie deep in the orbit whose removal with retention of the eyeball, the optic nerve and preservation of the normal movements of the globe is attended by considerable difficulty. This object is most successfully attained when the tumor is situated on the lateral side of the nerve.

4. For the drainage of a purulent deposit following an orbital periostitis.

5. As a preliminary to the operation for the ligature and removal of aneurisms and varices, *e. g.*, pulsating exophthalmus.

6. In the removal of retrobulbar fat in the treatment of the exophthalmus in exophthalmic goitre.

7. In the removal of foreign bodies imbedded in the apex of the orbit.

8. In opening the optic sheath for the relief of certain forms of choked disk.

OPERATIONS FOR THE REMOVAL OF ORBITAL AND INTRAOCULAR PARASITES.

Owing to the establishment of efficient governmental supervision of the stockyards, abattoirs, etc., both in this country and abroad, the ophthalmic surgeon is rarely called upon at the present day to operate for the removal of the *cysticercus* from any portion of the ocular ap-

[70]Czermak and Elschnig. *Augenärztliche Operationen*, Vol. I., p. 405

paratus. However, this parasite, as well as the *filaria loa*[71] and a few other animals, occasionally penetrate the interior of the eye and some form of surgical intervention is necessary for their extraction. The literature upon this subject emanates almost entirely from Germany, because it is in that country that the largest numbers of cysticercus accidents have occurred.

Operations for the Extraction of Ocular Cysticercus.

Von Graefe[72] was the first to remove a cysticercus from the depths of the eye. He made the extraction from the posterior chamber by means of a scleral wound; or, having previously extracted the transparent lens, he permitted the peripheral linear incision to heal and made another opening in the cornea through which he removed the parasite by means of a blunt hook. Later, he applied his linear extraction method (with iridectomy) to remove the cysticercus by making the incision downward and completed the operation at one sitting. For parasites in the anterior chamber (iris) he generally did an iridectomy.

Cysticercus in the Iris and Its Extraction.

When the animal attaches itself to and grows in the *iridic tissues* it can readily be examined by a lens and the oblique illumination and, as soon as the diagnosis is made, removed by an iridectomy. A most interesting example of this rare form of animal invasion occurring (strange to say) in the United States is described and pictured by Rembe.[73]

Stölting has also contributed several articles on this subject. (Consult his Beitrag zur Lehre von der Extraction intraoculer. Cysticerken, *Berliner klin. Wochenschr.*, 1889, No. 42, and Kann ein abgetöteter Cysticercus im Auge ohne Schaden verweilen? *Graefe's Archiv f. Ophthalm*, Vol. LIX, Part 1, 1904).

Operations for Echinococcus of the Orbit.

Cobbold defines the *echinococcus hominis* to be a small cestoid helminth, about ¼ inch long, which inhabits the intestinal canal of the dog, wolf and cat. The mature terminal link *(proglottis)* contains

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[71]See the complete monograph by Henry B. Ward, (Studies on Human Parasites in North America. I. *Filaria Loa. Journ. of Infectious Diseases*, Vol. 3, No. 1, p. 36), on this interesting subject. This parasite, when it invades the ocular structures, should receive the same operative attention as the cysticercus.

[72]Von Graefe. Weitere Beobachtungen über Zystizerken am und im Auge, *Archiv. f. Ophthal.*, III, 9, 1857, p. 308; and Zystizerken im Glaskörper, durch die Kornea extrahiert. *Archiv. f. Ophthal.*, IV, 2, 1858, p. 171. Consult also Bermerkungen über Zystizerkus, *Archiv f. Ophthal.*, XII, 2, 1866, p. 174.

[73]Rembe. Cysticercus Cellulosae of the Iris; Operation, with Perfect Recovery. *Ophthalmic Record*, Jan., 1907, p. 20.

about 5,000 ova; each ovum contains an embryo (*proscolex*). On entering the stomach of the host the embryo is liberated from the ovum by the action of the gastric juice, and bores its way through the stomachic or intestinal walls, and, by the blood-vessels or lymph-channels, finds its way into some solid organ, where it develops into a cyst *(scolex)*.

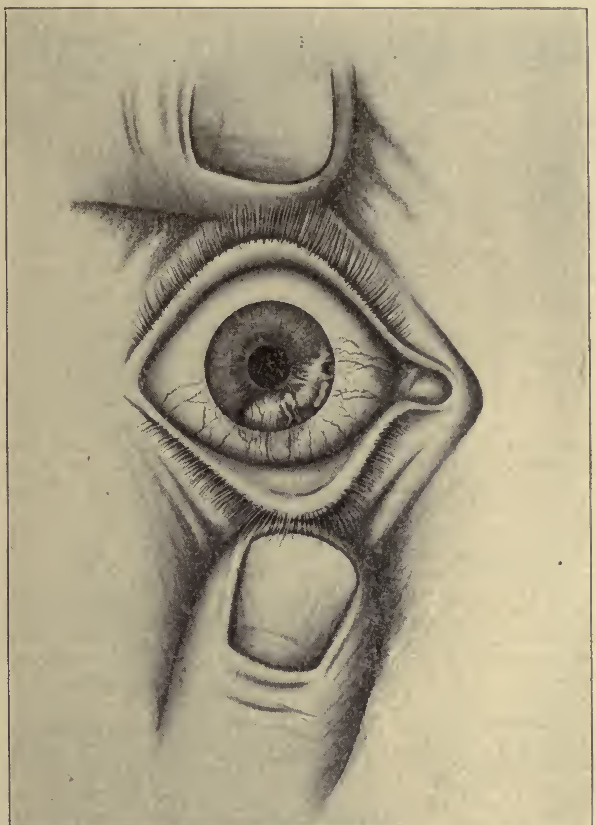

Fig. 402.
Cysticercus Cellulosa Iridis.

From the internal germinal wall of the scolex, or mother cyst, daughter cysts are formed.

Although the operative procedures proper to this parasitic invasion of the orbital cavities have been referred to yet the importance of it demands further mention.

The literature of the subject is rather large; yet the disease is comparatively rare. Collections of cases with their histories have been

made by Berlin[74], Dieu[75], Weeks, Mandour[76], Kraemer[77], Golovine[78], and others. Altogether, over a hundred cases of this disease have been reported to 1910.

John E. Weeks[79] gives a complete review of all (32) the cases of *echinococcus oculi* that he has been able to collect to the date of his paper. I take the liberty of quoting his conclusions and some points in diagnosis and treatment:—

"There is, of course, no reason why echinococcus cysts should not occur in any part of the body where the diameter of the arteries is more than the 1/400 of an inch, since this is about the diameter of the *proscolex* of the *tenia echinococcus hominis*. Echinococcus cysts have been found in the liver, spleen, lungs, brain, cord, muscle tissue, osseous tissue, and subcutaneous tissue. They have never been seen in the interior of the eye. The cyst may be simple, as observed by Mules or it may contain a large number of daughter cysts, as in the case reported by Lawrence.

Stellwag holds that the upper inner angle is the place of selection for the development of hydatid cysts in the orbit. However, this is contrary to the facts, as they have been observed equally as often in other parts.

The *growth* of the echinococcus cyst is usually very slow. In a case reported by MacGillivray the tumor was under observation six years before operative procedures were instituted. In the case described by the author, the tumor had been noticed but eight days before the operation.

The following symptoms have been observed: Pressure-pain in the eye, orbit or corresponding side of head; delirium, fever, chills, secondary glaucoma, loss of mobility, exophthalmus, diplopia, neuritis, loss of vision in varying degree. Fever occurs only when suppuration is taking place, disastrous results occurring almost always where operative procedure was not instituted in the early stages of the development of the tumor. Partial or total atrophy of the optic nerve, partial loss of mobility, sloughing of the cornea, panophthalmitis, and death are also noticed.

Diagnostic points. Pressure-pains referable to the back part of the eye, or to the temporal region, usually most severe at night; slow progressive development of exophthalmus; absence of fever; the presence of a firm, elastic, obscurely fluctuating, sometimes trembling tumor projecting from any part of the orbit; if connected with the brain, pulsation may be noticed; if on puncture with an aspiration-needle some clear fluid is drawn off, found to be *devoid of albumen*, but rich in sodium chloride (nitrate-of-silver test), the diagnosis of hydatid cyst is positive, even without finding hooklets, since the contents of all other cystic tumors are albuminous.

Radical operative procedure should be resorted to immediately on confirming the diagnosis, whether the tumor is confined to the orbit or not. Total extirpation when practical, or complete evacuation of the cyst, and the encouragement of a process to destroy the genetic membrane, as the insertion of a drainage-tube and the production of a mild process of suppuration, should be resorted to. In all cases where simple puncture, resulting in evacuation of the liquid, has been done, the cyst has refilled. In all cases where a suppurative process, without removal of the cyst wall, but thorough removal of its contents, has taken place, rapid recovery has followed."

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[74]Berlin. Krankheiten der Orbita. *Graefe-Saemisch Handbuch der ges. Augenheilk*, Vol. VI, 1880, p. 686.

[75]Dieu. Documents relatifs a l'histoire des kystes hydatiques de l'orbite. *Recueil d'Ophtalm.*, 1883, p. 713, and 1884, p. 6.

[76]Mandour. Étude sur les kystes hydatiques de l'orbite. *These de Paris*. 1895.

[77]Kraemer. Die thierischen Schmarotzer des Auges. *Graefe-Saemisch Handbuch der ges. Augenheilk.* 2nd ed., p. 41.

[78]Golowin, Uber Echinococcus der Augenhöle, *Zeitschr. f. Augenheilk.*, Bd. IV. Heft 6, 1900, p. 647.

[79]Weeks. A case of Epibulbar Echinococcus, with a Review of the Literature on Echinococcus Cysts of the Orbit. *Archives of Ophthalm.* No. 1, 1889, p. 31.

PART VI.

CHAPTER I.

THE OPERATIVE TREATMENT OF PTERYGIUM.

By WILLIAM T. SHOEMAKER, M. D., Philadelphia.

Origin of the Term—Pathogenesis—Site of Pterygium—Forms of Pterygia—Pseudo-Pterygium—Development of Modern Methods of Pterygium Operation—Preparation of the Patient—Selection of the Method—Removal of the Head of the Pterygium—The After-Treatment—The Method of Arlt—Hobby's Excision Operation—Lipscomb's Method of Excision—Desmarres Method of Transplantation—Knapp's Method—McReynold's Method—L. Webster Fox's Operation—Galezowski's Subvolution Method—Treatment of Pterygium by Skin-Grafting—Pseudo-pterygium and Recurrent Pterygium—Pinguecula.

From the time of the Ancients, surgeons have been interested in pterygium and its operative treatment, and it would seem almost remarkable that a structure so small, so uniform and so approachable, should have accumulated such an extensive literature, an amount, it might be said, disproportionate to the importance of the disease. A careful review of the literature will show, however, comparatively few names associated therewith by reason of additional knowledge of importance contributed to the subject.

Through centuries the name only has remained constant, the etiology, anatomy, pathology and therapy having undergone various changes and revisions until the present day, when we at least think we understand the true nature of the condition.

Pathogenesis.

Of Greek derivation the name pterygium means *"a little wing"* and has reference to the very characteristic if not constant appearance of this conjunctival structure, triangular in shape, with its apex, or head, at the corneal limbus or on the cornea, and extending backward, fan-shaped, to become lost in the bulbar conjunctiva near the inner or outer canthus, as the case may be. The true pterygium always has its origin in a pinguecula, a theory first promulgated by Horner,[1] and later estab-

[1]Horner. *Correspondbl. f. Schweitzer Aerzte,* 1875, p. 554; quoted from Yarr. The Pathology and Diagnosis of Pterygium, *Journal of Tropical Medicine,* 1, 6, 1899, p. 155.

lished by Fuchs.[2] According to Parsons[3], Zehender[4] first derived pterygium from pinguecula, but gave no proofs.

It is therefore only to be found on the nasal or temporal aspect of the bulbar conjunctiva within the palpebral fissure. Similar structures placed vertically above or below, which have been occasionally noted and reported, are not true pterygia, but are cicatricial conditions more of the nature of symblepharon, and were better nominated pterygoid or pseudo-pterygia.

From the *pinguecula* progress is made forward, and an attachment formed at the corneal limbus, from which point further progress and invasion of the cornea slowly take place until the head of the pterygium may occupy the very center of the cornea, or even pass beyond this point. The conjunctiva is thus passively drawn in the direction of the advancing head, the thickened and folded conjunctiva known as the body of the pterygium, with its diverging margins resembling very much the tail of a comet. The slightly constricted portion differentiating the head from the body, and always at or over the limbus, is called the neck. In the presence of a formed pterygium the pinguecula has disappeared. Pterygium is therefore not a new growth, but an overgrowth and displacement, and rearrangement of pre-existing tissue.

Site of Pterygium.

Primarily, pterygium always attacks the nasal side of the eyeball; not infrequently one will develop on the temporal side later. Yarr[5] states that he has never seen a single temporal pterygium. He believes that when one exists in this situation, it is always consecutive to one on the nasal side of the same eye. Both eyes are generally affected, although not necessarily at the same time, and occasionally the same individual will have four pterygia.

According to Saemisch[6] pterygium is twice as frequent in males as in females, and with few exceptions an individual with a formed pterygium has reached his fortieth year.

That pterygium may be malignant in the sense of being progressively destructive, is evidenced by the fact alone that its tendency is to advance steadily toward the pupillary area of the cornea and in this way destroy vision. Chisholm[7] for example, reported three cases of

[2]Fuchs. Zur Anatomie der Pinguecula. *Graefe's Archiv. für Ophthalmologie*, XXXVII, 3, p. 143, 1891; and Ueber das Peterygium,*ibid* XXXVIII, 2, 1892, p. 1.

[3]Parsons. *The Pathology of the Eye.* 1, p. 107, 1904.

[4]Zehender. *Handb. der ges. Augenheilk*, 1869.

[5]Yarr. The pathology and diagnosis of pterygium. *Journal of Tropical Mediaine*, 1, 6, 1899, p. 155.

[6]Saemisch. Graefe-Saemisch. *Handbuch der ges. Augenheilkunde*, V, 1, p. 417 (New Ed.).

[7]Chisholm. Pterygium completely covering the cornea. *Medical and Surgical Reporter*, LVIII., 1888, p. 633.

pterygium which had completely covered the cornea, one of which extended almost to the opposite limbus.

Similar cases have also been recorded by Ryerson.[8]

Commenting on the possibility of pterygium reaching the center of the cornea, Arlt said, "Authors who claim that pterygium rarely advances as far as the center of the cornea, never beyond it, must have seen little of the disease."

Cyst formation in a pterygium, cases of which have been reported by de Schweinitz[9] and by Strachow[10], and *epitheliomatous degeneration,* are changes occasionally noted. X. da Costa[11], of Lisbon, maintains the possibility of epitheliomatous transformation of the head of the pterygium, and describes two cases in which histologic examination showed a distinct epitheliomatous structure. Three similar cases are cited from different observers.

Such changes not only complicate the operative procedures then necessary, but their possible occurrence is an additional argument in favor of the removal of any pterygium.

That *recurrence* will at times follow any form of pterygium operation has been the experience of every surgeon, but it is well to bear in mind the observations on this point made by Czermak and Elschnig.[12]

These authors state that the really active part of a pterygium is the limbus portion. If this portion be carefully removed and the wound covered with conjunctiva, there can be no *true* recurrence. The conjunctiva may form here a cicatricial pterygium which differs materially from a true pterygium, and especially in that it is not progressive.

Forms of Pterygia.

The question of *activity* in a pterygium is a most important one, and one at times difficult to decide. Classed as *progressive,* and *stationary,* it becomes the surgeon's duty to determine first, which form is being dealt with. The importance of this lies not so much in the simple question as to whether or not to operate, for it is proper to operate upon any pterygium, for cosmetic reasons, and for the relief of accompanying chronic conjunctivitis, undue astigmatism, etc., but if *progressive,* operation should be urged as imperative. In other words,

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[8]Ryerson. Extreme cases of pterygium. *Medical Record,* XXXIX, 1891, p. 536.

[9]de Schweinitz. Recurrent pterygium treated by removal and the implantation of a Thiersch graft. *Transactions of the College of Physicians,* Phila., XXXI, 1908, p. 319.

[10]Strachow. Seltene Form des Pterygiums. *Klin. Montasblätter f. Augenheilkunde,* May, 1908, p. 563.

[11]daCosta. Quoted from Yarr. *Journal of Tropical Medicine,* 1, 6, 1899, p. 155.

[12]Czermak and Eischnig. *Die Augenärztliche Operationen,* 1907-1908.

the *stationary* pterygium *may* be operated upon, the progressive pterygium *must be,* and both *should* be.

Clinically, the *stationary pterygium* is, as a rule, thin, pale, and poorly defined; it contains but few blood vessels, not exceeding much in size those of the normal conjunctiva, and has a flat head of irregular outline, lying on or passing into the cornea with little perceptible elevation, and scarcely invading the cornea beyond the limbus. At times the head is bordered by a narrow, glistening or tendinous-looking line. The whole is evenly covered by epithelium. Such a pterygium is stationary.

The *progressive pterygium* on the other hand, is apt to be darker in color and more vascular, the vascularity seeming to be due to new-formed as well as enlarged pre-existent vessels. It is thicker, and the head shows material elevation, and is often bordered by a grayish, gelatinous-looking material free from blood vessels. Any great amount of vascularity in the neck, and approaching the head, is very suggestive of progress.

In classifying a pterygium as stationary or progressive, then, a careful examination and critical analysis of the head and neck must be made, and the clinical signs of activity will be found to be the same here as elsewhere in the body.

Pseudo-Pterygium.

The differential diagnosis between true and false pterygium is not difficult. *Pseudo-pterygium* is a fold of conjunctiva which has become adherent to the cornea at a point of previous ulceration or abrasion. The limbus is crossed by a *bridge* of conjunctiva beneath which a fine sound can always be passed. There is no canal beneath the neck of a true pterygium, and the passage of a sound at this point is impossible.

THE DEVELOPMENT OF THE PRESENT DAY METHODS OF PTERYGIUM OPERATION.

The first surgeons to operate for pterygium naturally practised simple excision or extirpation. This was followed by partial excision and various sections and resections.

Celsus[13] (Rome, A. D. 1) advised separation of the pterygium by a scalpel after lifting it from the sclera by a thread passed beneath. Aetius[14] sawed it from its attachments with a horsehair.

Heister[15] made a single incision through the pterygium, with the idea presumably, of eradicating it by destroying its circulation.

[13]Reference from Himly. *Die Krankheiten und Misbildungen des menschlichen Auges und deren Heilung*, p. 13 (footnote).
[14]Aetius. *Ibid.*
[15]Heister. *Ibid.*

Saint-Yves[16] cut through "cross-wise" and pulled the flaps away. Acrel[17] cut through the pterygium on the cornea, and according to Richter,[18] was the first surgeon to advocate and practise removal of the head. Scarpa[19] in the early part of the nineteenth century removed the head from the cornea with forceps, dissected backward freely, and three or four millimeters from the limbus separated the pterygium by an incision concentric to the cornea. Scarification of the pterygium in a direction perpendicular to its long axis was recommended by Benjamin Bell in 1813. Cauterization and scarification, after separation, were also practiced by Woolhouse and Beer, and caustics, such as silver, zinc, etc., were for a time used by others.

Coccius[20] was probably the first to introduce conjunctival sutures to cover the exposed sclera. He is thus credited by Arlt[21], although, according to Fuchs,[22] Arlt himself deserves the credit for having made the operation for pterygium a success by demonstrating the necessity of closing the conjunctival wound. Fox[23] on the other hand, gives this honor to Fano.

In 1842 the *method of ligation* was introduced by Szokalski.[24] Three ligatures were passed beneath the pterygium, one at the limbus, one near the base, and a double one in the middle. The inner and outer ligatures were tightly drawn and knotted, the middle one was used first to pull the pterygium from its scleral attachments, and was then tightened and the ends fastened to the cheek with collodion. After the death of the pterygium, which occurred in a few days, it was excised. This method in the opinion of the writer is, at the present day, both unnecessary and unsurgical, and while it is carefully described and illustrated in many text-books, no form of pterygium could warrant its selection.

About 1855, the elder Desmarres[25] devised the method of *transplantation* for the purpose of diverting the growth from the cornea. Not only was this object accomplished, but it was found that after transplantation the pterygium atrophied. Desmarres' principle was one of great and lasting value, and he must ever receive a royalty on the credit given any transplantation operation for pterygium.

The *actual cautery* as a means of destroying the head and neck

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[16]Saint-Yves. *Ibid.*
[17]Acrel. *Ibid.*
[18]Richter. *Treatise on Surgery*—Göttingen, 1771, p. 92.
[19]Scarpa. *Traité des maladies des yeux*, 1802-1816.
[20]Reute. *Lehrbuch der Augenheilk*, 11, 267, 1854.
[21]Arlt. *Die Krankheiten des Aughs*, 1850.
[22]Fuchs. *Text Book of Ophthalmology*. Am. Ed., 1908, p. 128.
[23]Fox. *Diseases of the Eye*, 1904, p. 129.
[24]Szokalski. *Rozer und Wunderlich Archiv*, 1845, No. 2.
[25]Desmarres. *Traité theorique et pratique des maladies des yeux*, 2d edition, 11, 1855, p. 168.

of a pterygium has been strongly advocated by Coe[26], and F. B. Loring.[27] Both Coe and Loring applied a heated platinum wire to the corneal and limbus portion of the pterygium. They believe that if these portions are destroyed, the body will disappear by atrophy. This method, simple as it is, has not many strong adherents.

Finally, the *weak galvanic current* (2-5 milliamperes) has been tried and reported upon favorably by Sharkey[28] and others.

The claims made for it are: 1. It coagulates the blood in the vessels, causing disappearance of the vessels. 2. It produces mild adhesive inflammation, forming a cicatrix between the conjunctiva and the sclera. 3. It destroys micro-organisms in the tissues. While the galvanic current might be tried, its results are so uncertain that the method must be classed as unreliable.

Practically, at the present time, the best operations for pterygium are those of excision, (ablation or abscission), and those of transplantation, (deviation or burying). The principles of each are fundamental and established, and while the modifications of modus operandi and technic are innumerable, there are, nevertheless, but few things to be done in any pterygium operation.

Before describing in detail some of the more important operative procedures, it might not be amiss to discuss certain points common to all.

Preparation of the Patient and for the Operation.

The time to operate is coincident with the first opportunity. Do not postpone operation until the head of the pterygium reaches the pupillary area, or "*begins* to interfere with vision." Vision lost in this way can never be fully regained. Furthermore, there is a nebulous zone around the head of a pterygium reaching beyond its visible or apparent margin.

Remember that a portion of the corneal epithelium and Bowman's membrane is to be removed, and left for a time unprotected, and that a very considerable portion of the conjunctiva is to be at least undermined. Infection under these conditions might be disastrous. Prepare the lids, lashes and conjunctival sac carefully, and in accordance with accepted methods of clean surgery. Do not operate in the presence of dacryocystitis or conjunctivitis with secretion. Local anesthesia is quite sufficient to render the operation painless. Cocain in 2 or 4 per cent. solution should be instilled in the usual manner. Solutions

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[26]Coe. A new method of treating pterygium. *Annals of Ophthalmology and Otology*, V, 1896, p. 250.

[27]Loring. The modern treatment of pterygium. *Medical News*, LXXXI, 211, 1902. See also same paper in the *Washington Medical Annals*, Jan., 1908.

[28]Sharkey. The galvanic current for the treatment of pterygium. *Jour. Am. Med. Assoc.*, 1898, p. 634.

stronger than 5 per cent. are dangerous and no more effective. Adrenalin chloride, 1-3000, may be added to the cocain or used separately if desired. While the immediate effect of adrenalin is good, subsequent congestion and hemorrhage are sometimes more troublesome than primary hemorrhage. The latter is, as a rule, not very severe and can well be cared for by an assistant with a pledget of cotton or gauze.

The *instruments required are not many.* A good speculum, which will hold the lids firmly and permit of a wide, even exposure of the eyeball; a Graefe cataract knife or one of the specially designed knives for removing the head; a broad-toothed forceps; a small blunt-pointed straight scissors; a flat strabismus hook; a fine sharp curette; a few small curved needles, and some fine silk, are all that are necessary for any incision or transplantation operation.

Selection of Method.

This is more a matter of preference and judgment on the part of the operator, than a point to be determined by text-book rules. If the pterygium is very large and thick, the writer often prefers excision because the excess of tissue is in that way radically removed, and the result he thinks is apt to be smoother. If the pterygium is of moderate size, transplantation would be selected, and if very small, the method would to him seem immaterial.

Removal of the Head.

In both operations of excision, and in those of transplantation, the head and neck of the pterygium must be carefully and completely removed. Ultimate success depends upon two factors, viz., *complete removal* of the head and neck from the cornea and limbus respectively, and the *complete covering* of all sclera exposed incident to the operation.

The head is best separated from the cornea by a sharp knife, although many operators prefer the method of evulsion by means of a flat strabismus hook as recommended by Prince.[29] A Graefe cataract knife answers the purpose very well, but in a deeply-placed eyeball, it is at times difficult to manipulate so as to transfix the neck tangential to the surface of the sclera, and shave the head smoothly from the cornea by passing the knife forward. For this reason several useful knives have been specially constructed to better meet the conditions. H. B. Young[30], for example, has ground the angular keratome of Jaeger into a kidney or pointless sickle-shape, sharp all around. (Fig. 403.) These knives are made right and left, and as the knife follows the contour of the globe, dissection is easier and cleaner.

[29]Prince. An accidental divulsion of pterygium, leading to an improvement in the regular operation. *Archiv. of Ophthalmology*, XIV, 16, 1885.
[30]Young. A new pterygium knife. *Ophthalmic Record*, XVII, 1908, p. 132

G. Melville Black[31] prefers Agnew's iridectomy knife made about 1/3 size. (Fig. 404.) The important point is to remove every vestige of the head, shaving down, if necessary, well into Bowman's membrane. Holmström[32], for the purpose of securing less opacity of the cornea after operation, advises the method of abscising the cornea advanced by Malgaigne and Szokalsky[33] for the removal of corneal opacities located in the superficial layers.

Evulsion of the head (Prince) is performed by introducing the tip of a strabismus hook beneath the neck, and then with moderate

Fig. 403.
Young's Knife.

force dragging the hook forward with a prying motion, tearing the head from its attachment. A clean and complete separation is thought to be to the advantage of this method, but in the opinion of the writer, cutting when possible is always better than tearing in ophthalmic surgery.

Cauterization and curetting of the corneal wound after the removal of the head have also been recommended. If the surgeon will be careful to have the corneal wound free and clean, it will make little

Fig. 404.
Agnew's Modified Iridectomy Knife.

difference which method of removal he adopts. The chances of recurrence will be minimized, and the after appearances of the eye enhanced by careful attention to this detail.

The Drake-Brockman Operation.

The figures show the ordinary form of corneal pterygium seen in

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[31]Black. The simple excision operation for pterygium, with a new instrument. *Ophthalmic Record*, VI, 1897, p. 650.

[32]Holmström. Zur operation des Pterygiens. *Klin. Monatsblätter f. Augenheilk*, XXXVIII, 1900, p. 550.

[33]Malgaigne and Szokalsky. *Hygiea*, Bd. 61, 6. 229.

India and the operation which the writer (p. c) has found effective for its removal. He believes that it will be found equally valuable elsewhere.

The apex of the growth is picked up by a very fine pair of forceps (iris or similar kind) and stretched so as to ascertain its final attachment to cornea. While on the stretch a small nick is made in it close to the cornea. Into this opening is gently inserted one point of a small pair of very sharp scissors and the growth divided close to the cornea until the corneo-scleral margin is reached on the upper side. Then the scissors blade is placed on the lower end and the growth duly divided below to a point opposite to it above. This leaves a triangular tongue of membrane attached by its base to the conjunctiva. Now the conjunctiva under the growth is well undermined both above and below, so as to allow the portions of the conjunctiva at the corneal margin to be brought together easily when suturing. This having been done with the scissors, a cut is made through the growth at a sufficient angle, corresponding in size more or less to the part over the

A

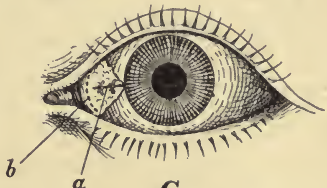
Fig. 405.

Pterygium Suitable for the Drake-Brockman Operation.

B

Fig. 406.

Drake-Brockman Operation for Pterygium. Exsection of Diamond-shaped Area.



C

Fig. 407.

Final Stages of Drake-Brockman Operation for Pterygium.

cornea and, ultimately, a diamond-shaped piece is excised and removed completely. (See figures.) A V-shaped opening now exists in the conjunctiva whose edges are sufficiently undermined above and below in order to adapt easily the incised edges which are then neatly brought together by two sutures. In the event of there being excessive tension after insertion of stitches, it is as well to incise the mucous membrane half way between the wound and inner canthus, as indicated by the dotted line. After completion of this portion of the operation it is as well to touch lightly with the electric cautery the portions of cornea to which the pterygium was originally attached, so as to prevent recurrence as far as possible. It is necessary, for the prevention of hemorrhage, to inject a drop of adrenaline and cocaine solution beneath the growth, and in order to obtain immediate union of the operative wound edges. Only very sharp instruments should be used in making the incisions. The electro-cautery is the most effective method of dealing with the corneal attachments of the growth, as being less likely to lead to patches of opacity, which are so often the result of operations for pterygium, especially when it is of long standing and much adherent to adjacent parts.

The After-Treatment.

This consists in absolute quiet for the patient, and immobilization of both eyes to insure if possible healing by first intention, and to prevent the tearing out of stitches. Two or three days will usually be sufficient time to keep both eyes bandaged, with an additional day or two for the operated eye. It is a mistake to keep an eye bandaged longer than absolutely necessary to secure a sufficiently firm union. Secretions accumulating back of closed lids do not aid in the healing process; it is better to flush the eye frequently with some cleansing solution, such as warm boric acid.

Stitches should be removed the moment they fail to be of service. Any stitch in the conjunctival sac is an irritant, and a loose useless stitch is an unnecessary irritant. A careful inspection of the stitches from day to day should be made, and the time for removal determined by their efficiency, rather than by an arbitrary rule. Few stitches are active after five or six days; if union has not been secured in that time, the chances are the wound will have to heal by granulation. If this is recognized, then the sooner the stitches are out the better.

Reaction following operation for pterygium is usually not severe, nor is there much pain or discomfort following the operation. It is the practice of the writer to instill atropin or scopolamium immediately after any operation of this kind on the eyeball. Post-operative discomfort is lessened; irritability and lachrymation are diminished, and more complete relaxation is obtained. The eye is placed in the most favorable condition for repair.

The after-results of pterygium operation vary according to the size and extent of the pterygium removed, and the skill of the operator in the selection of method and execution. With a large pterygium, or one of moderate size, there will always be remaining an indelible opacity of the cornea just within the limbus, a more or less thickened, and drawn or ridged condition of the conjunctiva *in situ,* and some yellowish discoloration, all of which appearances are far preferable and superior to those of the original condition.

Method of Arlt.[34]

Excision according to this method is one of the best and cleanest operations for pterygium, and gives, if properly done, a very satisfactory result.

After the usual preparations and the insertion of a blepharostat, or speculum, the neck of the pterygium is lifted from the eyeball by a broad-toothed forceps and transfixed with a Graefe knife parallel to the limbus at this point, and with the cutting edge directed toward

[34]Arlt. *Die Krankheiten des Auges*, 1, 1850, p. 164.

the center of the cornea. By a sawing movement forward the head is cut from the cornea. If one of the other forms of knife be used, the technic is changed accordingly. The liberated head is then held in the forceps, and with a small straight scissors, preferably blunt-pointed, the pterygium is dissected from its bed. The incisions above and below made by the scissors follow the margins of the pterygium backward toward the canthus (Fig. 408), and are therefore divergent in this direction. They are carried backward about 6 or 7 mm., but the body of the pterygium is undermined much farther;—about twice this distance. Two converging incisions are then made with the scissors through the body of the pterygium to meet in the median line near the canthus. These latter incisions commence where the first two incisions terminated. A quadrilateral piece of the pterygium is thus removed, leaving a similar area of the sclera to be covered by conjunctiva drawn from above and below. (Fig. 409.) It is well to undermine the conjunctiva above and below before introducing stitches

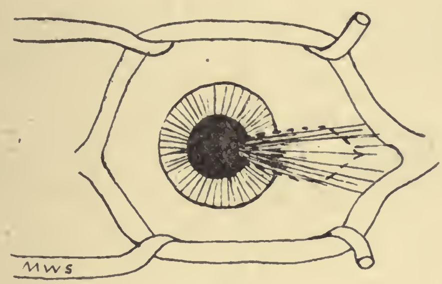


Fig. 408.

Arlt's Operation for Pterygium, showing the lines of incision.

to draw the two cut edges together. In this way undue tension is avoided and the result is smoother.

To prevent over-riding of the cornea when the conjunctival gap at the limbus is covered, two incisions several millimeters in length are made through the loosened conjunctiva at the limbus, one above and one below, tangential to the corneal margin at the point of operation. These incisions have been well named "*accommodation incisions.*" The number of stitches to be inserted will depend upon the size of the area to be covered. Suffice it to say that when the operation is completed, an unbroken horizontal line of carefully stitched conjunctiva should extend from the margin of the cornea backward toward the canthus, and no part of the sclera should be left uncovered. (Fig. 410.) The corneal wound should be treated as previously directed, and the rules for after-treatment observed according to the exigencies of the case.

If the pterygium were small, Arlt would often separate the head from the cornea, dissect a small portion only of the pterygium from the sclera, and unite the conjunctiva by several sutures at the limbus, or in front of the dissected portion. At times he would cut off the displaced tip, and sometimes he would leave it to atrophy and later disappear.

This procedure was also practised by Pagenstecher, and often bears his name. The writer can see no advantage in this rather abortive modification of a clean-cut operation, and should the operator select Arlt's excision method, would recommend that it be done in its complete form.

Hobby's Excision Operation.[35]

The conjunctiva is incised along the upper margin of the pterygium from the limbus to near the canthus. (Fig. 411.) A vertical in-

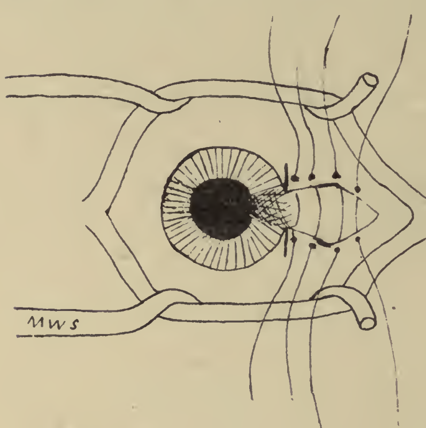


Fig. 409.
Arlt's Operation for Pterygium, showing scleral defect after removal of the "*accommodation incisions*," and the introduction of sutures.

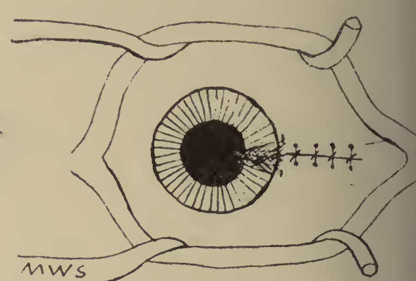


Fig. 410.
Arlt's Operation for Pterygium completed.

cision is made extending from the margin of the cornea upward at right angles to the first *(a.c)*. The pterygium is then removed from the cornea, and the incision *a.c.* continued downward to a point a little below the inferior margin of the cornea. *(d)*. An incision parallel to *a.b.* is carried along the lower margin of the pterygium. The pterygium is then dissected up and completely removed. The upper conjunctival flap is loosened from its attachments, drawn downward and united by several sutures, (Hobby inserts three) to the free margin of the lower flap.

[35]Hobby. An operation for pterygium. *American Journal of Ophthalmology*, 1888, p. 94.

The important claim made for Hobby's operation is that the line of conjunctival union is removed from the cornea, and from exposure in the palpebral fissure, and as recurrence after any excision operation is apt to take place in the cicatrix, the danger of recurrence is lessened.

Lipscomb's Method of Excision.

P. Lipscomb, of Texas, has devised the following operation which has the advantage of total extirpation of the pterygium, and the placing of the cicatrix in a position not favorable for recurrence:

The head is shaved from the cornea in the usual manner, and the body dissected free to its base, where it is removed with scissors. The conjunctiva below is undermined, and at the canthal portion an in-

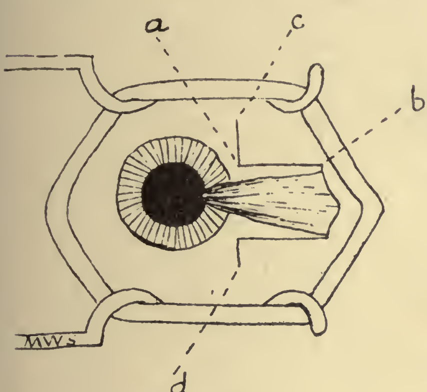


Fig. 411.
Hobby's Operation for Pterygium, showing lines of incision.

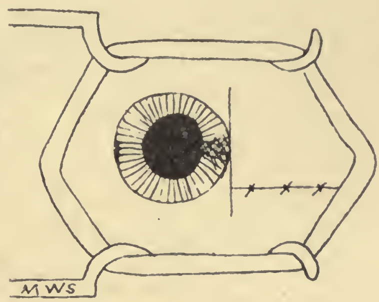


Fig. 412.
Hobby's Operation Completed.

cision is made concentric to the corneal margin. (Fig. a-b). The conjunctiva above is likewise undermined, and an incision (c-d) made at the limbus. The conjunctiva is then united by sutures, by carrying *a* to *e* and *c* to *f*, and of course suturing at intermediate points. The line of sutures and the following cicatrix will thus lie obliquely as shown in Fig. 413. Sutures may also be introduced along the line *e-b* if necessary.

From the standpoint of plastic surgery, this operation is ingenious, and would seem to meet well the indications.

As a modification of technic applicable in any operation in which the pterygium is totally extirpated, G. Edgar Dean, of Pennsylvania, introduced the galvano-cautery snare. After freeing the pterygium from tip to base, the conjunctival defect is covered. The loop of the snare is then thrown over the extruded mass, and the pterygium is actually burnt off at its base. Dean has never known a pterygium to recur when treated in this manner.

Desmarres' Method of Transplantation.[36]

By this, the first practised transplantation method, the pterygium is separated from the cornea, and its bed, back to its base. The tip is then transferred into a prepared angle or pocket in the lower fornix of the conjunctiva. After dissecting up the pterygium in the usual manner until it remains attached only at its base, an incision is carried downward toward the fornix through the conjunctiva, starting a few millimeters from the corneal margin. (Fig. 415.) In to this denuded angle thus formed, the head of the pterygium is fastened with a single stitch. (*a* Fig. 416.)

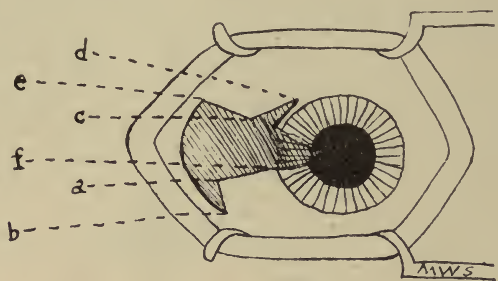


Fig. 413.
Lipscomb's Excision Operation for Pterygium, showing plan of removal and conjunctival defect.

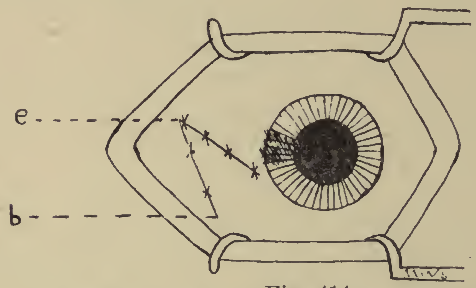


Fig. 414.
Lipscomb's Operation of Pterygium Completed.

Desmarres made no attempt to cover in the exposed sclera, but allowed the wound to heal by granulation. The operation is only described to show the origin of the transplantation method. It should not be performed to-day as Desmarres did it, as no surgeon would leave wounds to granulate that could just as well be covered. Important modifications, however, devised by Knapp[37] and McReynolds, have made from this operative principle very effective methods of disposing of pterygium.

[36] Desmarres. *Traité theorique et pratique des maladies des yeux*, 2nd Edition, 1855.

Knapp's Operation.[37]

Knapp describes his method as *double transplantation and covering the defect with conjunctival flaps.* The technic of the operation, following closely the author's own description,[38] is as follows: Remove the head from the cornea. Incisions made with small curved scissors are then carried along the lower and the upper margins of the pterygium toward its insertion into the semi-lunar fold, and prolonged into the lower and upper fornix respectively. (Fig. *a* and *b*). The pterygium is then detached from the sclerotic and the head cut off. The conjunctival defect after the pterygium is dissected back to its base is shown in Fig. 418.

With a pair of straight scissors, the pterygium is then split into two symmetrical halves by a horizontal incision. (Fig. 419.) The tip of the lower half is then stitched into the apex of the triangular defect in the lower conjunctival fornix, and the tip of the upper half is like-

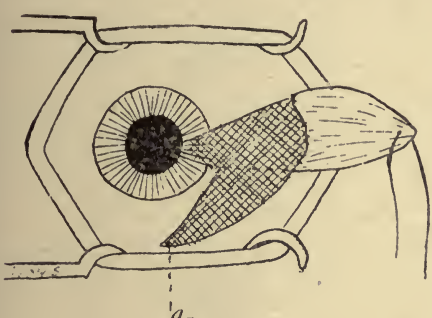


Fig. 415.

Desmarres' Transplantation Operation for Pterygium, showing Pterygium dissected back to its base, and prepared angle *a*, into which head is to be stitched.

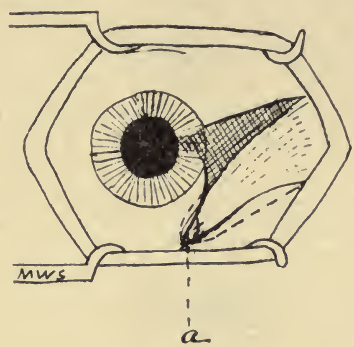


Fig. 416.

Desmarres' Operation, showing Pterygium transplanted into lower Fornix.

wise stitched into the upper conjunctival fornix. To cover the defect, Knapp makes two *"accommodation incisions"* as shown in Fig. 418, then introduces two stitches—one next to the limbus, and the other at the caruncular end of the defect. The latter stitch should, he says, include the tissue forming the apex of the angle behind the two halves of the split pterygium. The operation as finished is shown in Fig. 420.

McReynolds' Method.

McReynolds[39], of Dallas, Texas, made in 1902, a very important

[37]Knapp. Ueber einige neue, namentlich plastiche Conjunctivaloperationen. *Archiv. für Ophthalmologie*, Bd. XIV, 1, 1868, p. 267.
[38]Knapp. *Norris and Oliver's System*, 111, p. 836.
[39]McReynolds. The nature and treatment of Pterygia. *Jour. Amer. Med. Assoc.*, Aug. 9, 1902.

contribution to the surgery of pterygium. His operation, which is an ingenious modification of Desmarres' idea, possesses certain merits which have gained for it great popularity in this country.

It is easy of execution, no tissue is removed, unless perhaps it is the head of a large pterygium, and that is optional, no exposed sclera remains; the conjunctiva which covers the site of the pterygium is applied smoothly in its new position; if well done recurrence is exceptional; it is applicable to pterygia of any size, and it calls for but one stitch.

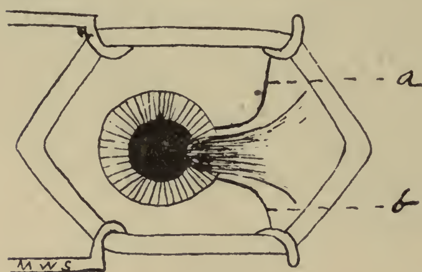


Fig. 417.
Knapp's Operation for Pterygium, showing primary incisions, *a* and *b*.

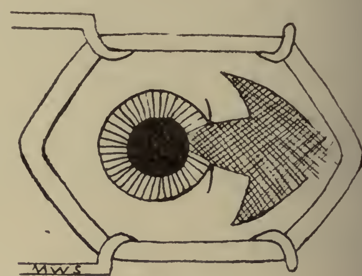


Fig. 418.
Knapp's Operation for Pterygium, showing conjunctival defect and "*accommodation incisions.*"

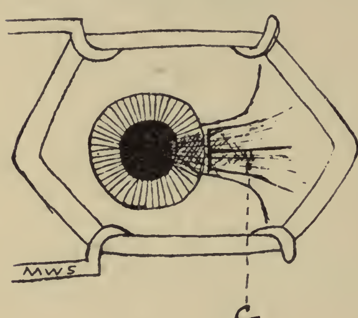


Fig. 419.
Knapp's Operation, showing dissected pterygium split into symmetrical halves by incision, *C*.

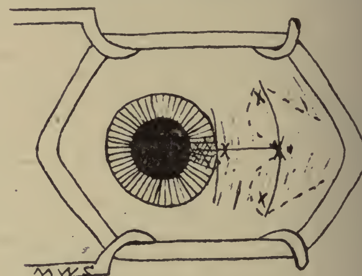


Fig. 420.
Knapp's Operation Completed.

Technic. Transfix the neck of the pterygium with a knife, and shave the head smoothly from the cornea. Hold the tip of the pterygium with fixation forceps, and with slender, straight scissors divide the conjunctival and sub-conjunctival tissues along its *lower margin* from the neck to the canthus. (Fig. a-b).

Separate the body from the sclera with any small non-cutting instrument, such as the closed blunt scissors, or a flat strabismus hook. Undermine the conjunctiva, lying below the oblique incision made with

the scissors. A pocket is thus formed into which the pterygium is to be buried.

A black silk thread armed at each end with a small curved needle is passed through the apex of the pterygium, placing the loop on the under surface. The needles are then passed downward beneath the undermined conjunctiva, and brought out in the lower fornix, one about 1/8 or 1/4 inch above the other, and both well over toward the vertical meridian of the cornea.

With these threads the pterygium is drawn downward into the sub-conjunctival pocket made for it. To facilitate this stage of the operation, the conjunctiva is at the same time raised with a forceps. The threads are then tightened, tied and cut. It is very important

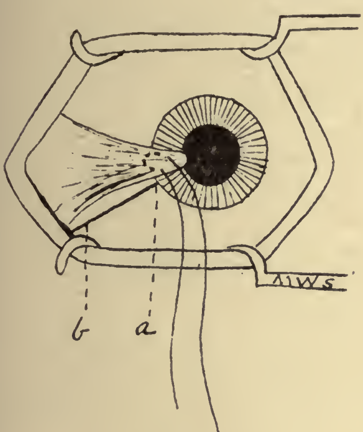


Fig. 421.
McReynolds' Operation for Pterygium, showing incision (a-b), and the suture passed through the tip from within out.

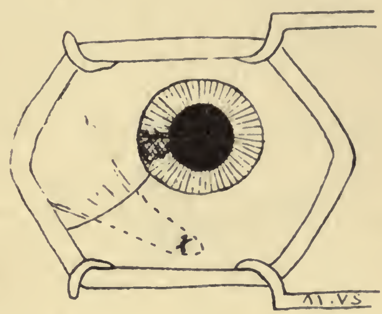


Fig. 422.
McReynolds' Operation Completed.

that no incision of any kind be made along the upper border of the pterygium. Such would cause a denuded space when traction was made upon the pterygium in drawing it into its new position.

Beard[40] urges as a practical suggestion in performing the operation, that the speculum be removed before proceeding to draw the pterygium into the prepared pocket. The effect of the speculum, he claims, is to greatly limit the extent to which the conjunctiva can be drawn downward, by pushing that member up into the fornix. The suggestion seems to be a good one.

Method of Fox.

Another method of transplantation practised and recommended by

[40] Beard. *Ophthalmic Surgery*, 1910, p. 346.

L. Webster Fox[41] is performed as follows: An incision is made in the conjunctiva along the upper and lower margins of the pterygium as shown in Fig. 423.

The conjunctiva below is undermined or pocketed as far as the insertion of the inferior rectus muscle. The pterygium is then separated from the sclera with scissors, leaving, however, the corneal attachment intact. A double-armed thread is passed through the tip of the pterygium close to its corneal attachment. The head is then separated by a strabismus hook or knife, and carried into the newly formed cul-de-sac below. The needles are passed through the conjunctiva near the insertion of the inferior rectus muscle and tied, firm-

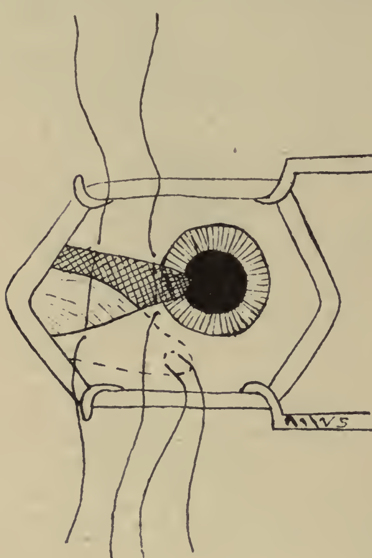


Fig. 423.

Fox's Simple Transplantation of pterygium with conjunctival sutures.

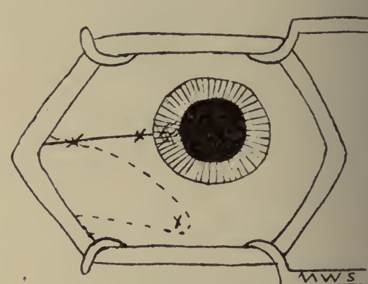


Fig. 424.

Fox's Simple Transplantation of pterygium with conjunctival sutures. Operation completed.

ly holding the pterygium in its new position. The cut edges of the conjunctiva above and below are brought together with two or three stitches. (Fig. 424.) Although no mention is made of it by Fox in his description, *"accommodation incisions"* at the limbus would aid in the replacement of the conjunctiva. The operation is simply an elaboration of Desmarres' original operation.

Subvolution or Subinvolution of the Pterygium.

This method was practised by Galezowski.[42] The pterygium was

[41]Fox. Text Book. *Diseases of the Eye*, 1904.
[42]Galezowski. *Maladies des Yeux*, 1888.

separated from the cornea and sclera, and a double-armed thread passed through the tip. It was then doubled on itself by carrying its head beneath to be stitched to the base. Conjunctival sutures were introduced to cover the defect.

The same operation was later advocated by Bettman[43] in this country, who gave to it the very appropriate name of *subvolution* or *subinvolution.*

Bettman claims that by thus placing mucous membrane against the sclera there can be no adhesion, consequently no recurrence.

Treatment by Grafting.

In dealing with very extensive pterygia and especially with those that have undergone cystic degeneration or epitheliomatous changes, it is sometimes impossible to leave sufficient bulbar conjunctiva to properly cover the defect after removal. In such cases the surgeon may have recourse to mucous membrane grafts as described by Klein[44], or to Thiersch skin-grafts after the method of Hotz.[45]

Hotz gives skin grafts decided preference over mucous membrane grafts. They are more easily handled and fitted; they require no sutures; they grow better and shrink less; they are as smooth as the surrounding conjunctiva, but look paler and more whitish.

An epidermic graft a little smaller than the area to be covered is shaved from the arm or other suitable place and transferred directly to the denuded surface of the eyeball. It is carefully fitted and the eye dressed. The graft becomes adherent in about three days. The method of Hotz under proper indications has proven to be a valuable adjunct to the surgery of pterygium.

Having thoroughly cleansed the surface from which the graft is to be taken, a wide sharp razor is drawn with a to-and-fro motion, removing the outer layers of the skin only. While most operators keep the razor flooded with warm sterile salt solution while detaching the graft, Beard[46] says that the operation is greatly facilitated by having the skin and the razor *perfectly dry.* The area to be covered must be free from blood before the graft is applied. The graft is transferred directly from the razor blade to the conjunctival defect, and there trimmed with scissors to properly conform. The lid is carefully closed so as not to displace the graft, and the eye dressed.

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[43]Bettman. Subvolution, a new pterygium operation. *Chicago Medical Record,* 6-7, 1894, p. 1.

[44]Klein. *Allgem. Wiener med. Zeitung,* 3-4, 1876.

[45]Hotz. A few experiments with Thiersch's grafts in the operation for pterygium. *Jour. Am. Med. Assoc.*, XIX, 11, p. 297. See also *Klin. Monatsbl. f. Augenheilk,* 1897, p. 610.

[46]Beard. *Ophthalmic Surgery,* p. 316.

Pseudo-Pterygium and Recurrent Pterygium.

The recurrent pterygium, it will be remembered, is not a true pterygium, but is, as a rule, a cicatricial structure. Occasionally, after removal or repeated removal of pterygium, a sclerotic degeneration of the cornea takes place, resembling very much what is known as *keloid-cornea.* In an exaggerated form the movements of the eyeball may be restricted, or the eyeball may be drawn into strabismus. It is the advice of Knapp, Beard and others not to interfere in these complicated cicatricial conditions unless it is absolutely necessary. Gifford[47], on the other hand, says that his experience indicates that all of these bad cases of recurrent pterygium can be cured if a large enough Thiersch flap or epithelial lip-flap is put on. He further says:

"In doing the operation, it is important, in dissecting back the conjunctiva, to clean the cornea and sclera very thoroughly, and to be sure that the flap is well attached to the globe before the lids are allowed to close. The devices which I have adopted of fixing the globe in position of abduction by means of a guy-thread put through the tendon of the external rectus and fastened to the skin outside the external canthus with collodionized gauze to prevent displacement of the flap, may be necessary in some extreme cases. But if the flap is pressed down firmly with an absorbent cotton toothpick swab, slightly moistened, so as to bring the entire under-surface into close contact with the globe, and the lids are held open for three to five minutes thereafter, then both eyes kept closed with a rather firm bandage, with plenty of cotton, for 48 hours, failures from displacement of the flap will be rare.

In applying the latter it is sometimes necessary to tuck the edges in under the loosened conjunctiva, and I have once or twice protected the well-applied flap by temporarily drawing the conjunctiva partly over it with a suture. The flap should be slid directly from the razor to the globe. It should be cut large enough, and, after covering the defect on the globe, the excess on the temporal side is trimmed off so as to leave bare the cornea, and a strip of sclera about 1-16 inch wide between it and the flap."

Surgical procedures for the relief of these distressing conditions other than grafting, are well summarized by Beard, who says:

"In its surgical treatment, false pterygium involves many of the principles which are concerned in operations for symblepharon as well as most of those described in connection with the true form: No set methods can be laid down for their operative handling, as they present so great a variety that each case must be separately reckoned with."

PINGUECULA.

For cosmetic reasons pinguecula is occasionally removed. The operation is without difficulty or danger. Simple excision with the insertion of a single stitch is all that is necessary. There should be no complications or sequelæ. Another method less desirable is by the use of the cautery.

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[47] Gifford. Recurrent Pterygium. *Ophthalmic Record*, Jan., 1909.

CHAPTER II.

OPERATIONS AND OTHER SURGICAL TREATMENT FOR THE RELIEF AND CURE OF TRACHOMA.

By JOHN GREEN, Jr., A. B., M. D., St. Louis, Mo.

Surgical Anatomy of the Conjunctiva—Pathology of Trachoma—Historical Review—Stages of Trachoma—MacCallan's Classification—Classification of Surgical Measures for the Relief of Trachoma—Advantages of Surgical Treatment—Expression of the Trachoma Bodies—Best Period for Expression—Anesthesia in Roller Operations—Objections to Expression—Grattage of the Conjunctiva—Curettage of the Trachoma Bodies According to Sattler—Massage—Brossage—Darier's Operation—Cauterism—Galvano-Cautery—Electrolysis—Electrolysis After Preliminary Scarification—Operation of Lindsay Johnson—X-Ray Treatment—Treatment by Radium—Simple Excision—Combined Excision—Modifications of Combined Excision—Extirpation of the Tarsus—Subconjunctival Injections—Miscellaneous Procedures—Operations for Pannus—Summary.

SURGICAL ANATOMY OF THE CONJUNCTIVA.

The normal conjunctiva is divided anatomically into three parts, the *conjunctiva palpebrarum,* the *conjunctiva fornicis* and the *conjunctiva bulbi.* Histologically, it consists of two layers—epithelium and substantia propria.

The *epithelium* varies in different parts of the conjunctiva. In the intermarginal zone, it is flattened and the middle layer consists of "prickle" cells, so that, histologically, the membrane at this site bears a close resemblance to epidermis. Elsewhere, while varying in the character and distribution of its epithelium, the membrane presents the histologic features of mucosa.

The *substantia propria* consists of a superficial adenoid and a deep fibrous layer. The meshes of the adenoid layer contain lymphocytes which are greatly increased in conjunctivitis, giving rise to "pseudo-papillæ."

Important histologic elements are the "goblet cells" (found in all parts of the membrane) and which, according to Parsons,[1] are "true

[1]Parsons. *The Pathology of the Eye*, Vol. I, p. 33.

unicellular mucous glands, moistening and protecting the conjunctiva and cornea." Baumgarten's tubular glands occur in the nasal part of the lid, and Krause's accessory lachrymal glands lie mostly in the upper lid between the fornix and the edge of the tarsus. The semilunar fold represents the nictitating membrane of birds and the caruncle is a little island of skin.

In section the conjunctival surface appears uneven, owing to the development of adenoid tissue in the substantia propria.

In commenting upon the structure of the conjunctiva in relation to the pathology of the membrane, Parsons[2] states that "there is a fundamental difference in different parts which manifests itself in the specific character of various pathological conditions and in their punctilious limitation to definite areas."

Pathology of Trachoma.

Parsons[3] divides trachoma into two forms, the papillary and the granular. The papillary form, limited to the conjunctiva tarsi, presents a velvety surface from the formation and hypertrophy of pseudopapillæ. The granular form exhibits grey translucent hemispherical bodies, the so-called "frog's spawn" or "sago-grain" masses, which are situated chiefly in the transition folds. In the conjunctiva tarsi the granules are smaller, bright yellow and hidden by papillæ. They tend to involve the tarsus and are *pathognomonic of trachoma.* The granulations are found in the upper tarsus, the lower tarsus, the caruncles and adjacent conjunctiva, but are most profuse between the upper margin of the upper tarsus and the fornix. The process of retrogression results in the formation of a network of cicatricial striæ which invades the enclosed hyperemic islands till the whole becomes pale, thin and smooth. In the fornices the folds are smoothed out and the conjunctiva shortened; a process which, combined with changes in the tarsus, leads to entropion. The shortening may obliterate the fornix and lead to posterior symblepharon. If glandular function is greatly impaired, the final outcome may be xerosis of the conjunctiva.

"The essential anatomical feature of all clinical types of trachoma, whether papillary, granular, mixed or gelatinous, is the trachoma follicle."

The follicles occur in the preformed adenoid layer of the conjunctiva, and consist of (1) a stroma which is equivalent to the reticular tissue of the adenoid layer of the conjunctiva, (2) lymphoid elements in the meshes of the stroma, (3) vessels which surround the follicle and send sparse capillaries into it, and (4) an inconstant fibrous tissue capsule. The epithelium is invariably thickened or may assume an epidermal character. Cysts may

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[2]Parsons. *The Pathology of the Eye*, Vol. I, p. 30.
[3]Parsons. *Pathology of the Eye*, Vol. I, p. 60 et. seq.

occur from the blocking of new-formed tubular glands. Changes in the conjunctiva are always present. There is widespread infiltration with lymphocytes, accompanied by edema, after the disappearance of which new vessels appear in the papillæ. Fibrous tissue develops along the walls and contracts, the papillæ shrinking. Trachoma ends in cicatrization most often by (a) absorption of the contents of the follicle and proliferation of the connective tissue of the conjunctiva; less often (b) by the contents of the follicles being expelled into the conjunctival sac, the resulting ulcer healing by cicatrization. Occasionally resorption by retrogression without softening may occur. New fibrous tissue is chiefly derived from the adventitia of the blood vessels. The process invades the neighborhood of the follicles and connective tissue and eventuates in scar tissue, there being no trace of follicles at last. The tarsus is primarily affected and, by contraction of the conjunctival fibrous tissue, is bent so as to make the convex surface look forward. Occasionally the tarsus may shrink in size without bending. There may be ectasia of the ducts of the tarsal glands with subsequent atrophy of acini due to an overgrowth of bands of fibrous tissue.

Fig. 425.

Trachoma Follicles in the Adenoid Tissue of the Transition Fold. The Follicle on the Left has Ruptured.

Historical Review of Trachoma Operations.

Trachoma is a disease of great antiquity. We are assured by Hirschberg that it existed fully three thousand years ago, though relatively less prevalent than at the present time. It is well described in Greek and Roman medical writings. Cicero, Pliny and Horace were victims of the malady.

Ancient and mediæval surgeons, realizing the all too frequent inefficacy of medical measures in the treatment of this most intractable disease, had resort to various mechanical and rude surgical procedures. Scarification and curettage were practised by the Arabians a thousand years ago. Hippocrates alludes to "scraping" of the granulations. Dioscorides rubbed the trachomatous conjunctiva with a fig leaf until blood appeared. A rubbing operation, known as "blepharoxysis," was devised and practised by Paulus of Ægineta.

After denuding the conjunctiva he applied powdered drugs or the actual cautery.

The *modern treatment of trachoma,* both medical and surgical, dates from 1812-13 when the French troops, returning from Egypt, imported the disease into the continent of Europe. At a period when bleeding was regarded as a *sine qua non* of correct therapeusis it is not surprising that surgeons should have practised depletion of the conjunctiva in the hope of checking the disease. It is stated that great quantities of blood, even up to several pints, were abstracted. In addition, leeches were used, and blisters were applied.

In 1811 Rust suggested excision of the conjunctiva, a method that was first put in practice by Elbe in 1839.

Van Lil, in 1849, made the important observation that granulations situated in the upper cul-de-sac and which were not eradicated by methods then in vogue, gave rise to recurrence after apparent cure.

In 1854 Pilz incised the individual follicles with a cataract needle and squeezed out their contents, thus laying the foundation for the method of scarification and curettage, later practised by Sattler. Borelli, in 1859, brushed out the follicles with a brush made of thin metal wire. Thus originated "brossage," a method which has found much favor among the French.

The observation that the upper conjunctival fold or fornix was the seat of predilection of the trachoma granulations induced Galezowski, in 1874, to practise excision of the transition fold. As a natural development of this truly meritorious idea came Heisrath's suggestion that, in those cases in which the tarsus was indubitably involved in the process, a tarsal strip should be excised along with the conjunctival fold. The unquestioned efficacy of this procedure in certain inveterate cases induced Kuhnt, who practised in a region where trachoma was endemic, to adopt it as a routine. As the outcome of an extended operative experience, Kuhnt finally settled upon three operative procedures as follows: (1) Simple excision of a strip of infiltrated fornix; (2) combined excision, i. e., removal of a part of the tarsus at the same time that a strip of infiltrated fornix is excised, and (3) extirpation of the tarsus (retaining the overlying conjunctiva).

It had long been known that pressure applied to a follicle-bearing conjunctiva would cause a rupture of the granulations and consequent escape of their contents. Pressure was originally made by the thumbnail—*unguipressio*—and this method was practised successfully and earnestly advocated by Hotz in 1886. The substitution of an instrument, the trachoma forceps, was a natural development and there followed in quick succession the instruments of Hotz, Prince, Noyes and

others. In 1891, the method received a tremendous impetus when Knapp devised his highly ingenious "roller" forceps. The profession all over the world was quick to recognize the peculiar merit of these fluted rolling cylinders and the method of "expression," thereby made practical and easy even for those unskilled in ophthalmic surgical technique, has more than held its own against all operative innovations in the treatment of trachoma.

In this brief outline it is impossible to do more than allude to other meritorious procedures, such as curettage, grattage, massage, cauterism, electrolysis, the use of the X-ray and radium, the operations for pannus, canthoplasty, etc., all of which will shortly be discussed in detail.

Stages of Trachoma.

Trachoma being a chronic disease passes during its long course through several more or less well-defined phases.

The value of a subdivision based on the clinical aspect of the various stages of the disease as an aid to a clearer conception of its progress, has been generally recognized. An exact appreciation of just how far the process has advanced is indispensable to one who desires to employ the most appropriate surgical measure.

I have had the good fortune to secure from Mr. A. F. MacCallan, Chief Inspector of Ophthalmic Hospitals in Egypt, a classification remarkable for its clarity and comprehensiveness. I quote from his personal communication as follows:

"Trachoma is a condition of the mucous membrane of the eyelids, in which gross changes occur, resulting in the formation of so-called granulations (with or without a papillary hypertrophy), which, in favorable cases, disappear, and are replaced by connective tissue.

Trachoma may be *divided into four stages*, classified according to the comparative prominence of the three features, granulations, papillary hypertrophy, and connective tissue formation.

Trachoma I is the beginning of the disease, and trachoma IV is its end when a cure has resulted (either naturally or as the result of treatment).

Trachoma I.—One finds on the conjunctiva of the tarsus and of the superior cul-de-sac, especially at the two extremities of the tarsus, slight roughnesses, forming grayish or grayish-yellow islands which are semi-transparent and almost avascular, with small blood vessels converging towards them. These roughnesses generally resemble grains of sago. There may or may not be a mucous discharge.

The simple form lasts a variable time, sometimes as long as a year, but after the development to a certain degree of the granulations, the conjunctiva becomes more vulnerable, and complications with a species of conjunctivitis other than trachoma usually occur.

This form may pass into trachoma II, or, in favorable cases or cases which have been treated, into trachoma III or IV.

Trachoma II.—In trachoma II there is usually a discharge and it is in this stage that the disease is especially infective. It is the stage in which granulations are numerous and large, or in which a papillary hypertrophy is present. It may be divided in the above sense into trachoma IIa and trachoma IIb.

Trachoma IIa. Gelatinous granules are present all over the tarsi and in the upper fornix. In some cases the individual granulations can no longer

be distinguished, they fuse into tumor-like masses or merge into a general infiltration, the tissue assuming a peculiar glassy gelatinous appearance.

Trachoma IIb. There is formation and hypertrophy of pseudo-papillæ consisting in red raspberry-like elevations which mask more or less the typical gelatinous granules. This papillary form, as it is called, is especially marked on the upper tarsus. This form may be mistaken for spring catarrh and for a condition occurring as the result of any long-continued irritation or of a protracted attack of purulent ophthalmia in a non-trachomatous eye.

Trachoma III.—In this stage cicatrization has definitely begun, and is more or less advanced. Islands of inflamed conjunctiva or of trachomatous granules are seen to be surrounded by a net-work of fine lines of connective tissue. It is in this stage that necrosis often results from the pressure of the shrinking connective tissue (post-trachomatous degeneration). The necrotic tissue may become calcareous. The cicatrization, which is typical of this stage, is generally supposed to be pathognomonic of trachoma.

Trachoma IV.—This is a condition in which there is a smooth conjunctiva seamed by white lines of connective tissue. This is the stage of practically complete cicatrization of the conjunctiva, or of cured trachoma.

I am aware that there are many cases which cannot be definitely stated to belong to one or other category; for instance, a case may be between trachoma II and trachoma III, or trachoma IV. But it is my experience that this division of trachoma is a valuable means of differentiating between its various phases."

Classification of Surgical Measures for the Relief of Trachoma.

Beard[4] classes surgical measures as follows:

1. Mechanical:
   - (a) Scraping or scratching.
   - (b) Expression or squeezing.
2. Chemical:
   - (c) Cauterism.
   - (d) Radiation.
3. Operative:
   - (e) Curettage.
   - (f) Excision.
   - (g) Canthotomy (and canthoplasty).
   - (h) Peritomy (and peridectomy).

Advantages of the Surgical Treatment of Trachoma.

"The object in treating this disease must be to procure speedy outlets for the follicles and to effect such changes as will destroy the vitality of the organisms, or, at any rate, decompose or render harmless the poison present." (Lindsay-Johnson.)

With the radical removal of the trachoma follicles, which give rise to scars and are responsible for the all-too-frequent relapses, a quicker and more lasting cure is certainly attained. Thirty years ago surgical measures were universally distrusted. The last decade has witnessed the all-but-universal acceptance of surgical measures as the *sine qua non* of rational therapy in this malady. Pick[5] states that the

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[4]Beard. *Ophthalmic Surgery*, 1910, p. 356.

[5]Pick. Zur des Trachomas. *Viereljahresch. für die prakt. Helik.*, Vol. XLII, p. 73.

special advantages of surgical treatment consist in: (1) Shortening the period of treatment; (2) lessening the liability to relapse; (3) favorably influencing the corneal complications; (4) obviating the wretched sequelæ of the disease. Despite the changed attitude of the great majority of ophthalmic surgeons, there still remain a few who either deny the efficacy of any surgical measure, or affirm that surgical are no more efficacious than non-surgical measures.

Expression of the Trachoma Bodies.

The idea of squeezing out the contents of the follicles with thumb and finger—*unguipressio*—is an ancient one of uncertain origin. It was used and advocated by Eble (1828), Pilz (1854), Cuignet (1873), E. Berlin (1878), Leber (1878), Wolfe (1882), and Mandelstamm (1883). In the United States Hotz[6] was one of the earliest advocates of expression. According to Beard[7] he devised the original expression forceps by smoothing the jaws of a pair of old angular forceps.

In 1889, Prince presented to the Illinois Medical Society his well-known ring forceps. Shortly afterward appeared the trough-shaped forceps of Noyes, and from this time the operation began to receive general acceptance.

Knapp's Roller Forceps.

It was not, however, until Knapp[8] presented to the profession his ingenious roller forceps that expression of the trachoma follicles became practically universal.

After experimenting in a few cases with Prince's and Noyes' forceps, it occurred to Knapp that an instrument acting on the principle of a mangle would express the granulations as well and with less bruising and laceration of the tissue. Acting on this idea, he had made the "roller forceps," which consist of "two creased cylinders, about two millimetres thick and ten or eleven millimetres long, rolling on pivots in horseshoe-shaped ends at the shafts." To insure rolling the surface of the rollers must offer resistance, hence the creases.

I append Knapp's[9] description of the technique of expression of trachoma granules with roller forceps:

"To express trachomatous infiltration both thoroughly and with the

[6]Hotz. The Excision of the Retrotarsal Folds, and Other Procedures Against Trachoma. *Archives of Ophthal.*, Vol. XV, 1886, p. 147.

[7]Beard. *Ophthalmic Surgery*, 1910, p. 358.

[8]Knapp. Demonstration of a Roller-Forceps Constructed According to the Mangle Principle for Pressing out Trachoma Granulations, with Remarks. *Trans. Am. Ophthal. Soc.*, 1891, p. 148.

[9]Knapp. Norris and Oliver. *System of Diseases of the Eye*, Vol. III, p. 850.

proper care not to wound the cornea nor bruise or lacerate the conjunctiva, is painful and requires time. I therefore, as a rule, use general anesthesia. As the operation has proved harmless, I operate on the four lids at the same sitting. The upper lid when everted should be seized at its edge with the (roller) forceps at the center of the retrotarsal fold drawn upward, so that the whole extent of the granular deposition shall be exposed. Then the lid is held everted with the index-finger, and one cylinder is pushed deep into the upper fornix over the edge of the lower lid, which, remaining *in situ*, protects the cornea. The other cylinder passes over the tarsal surface of the

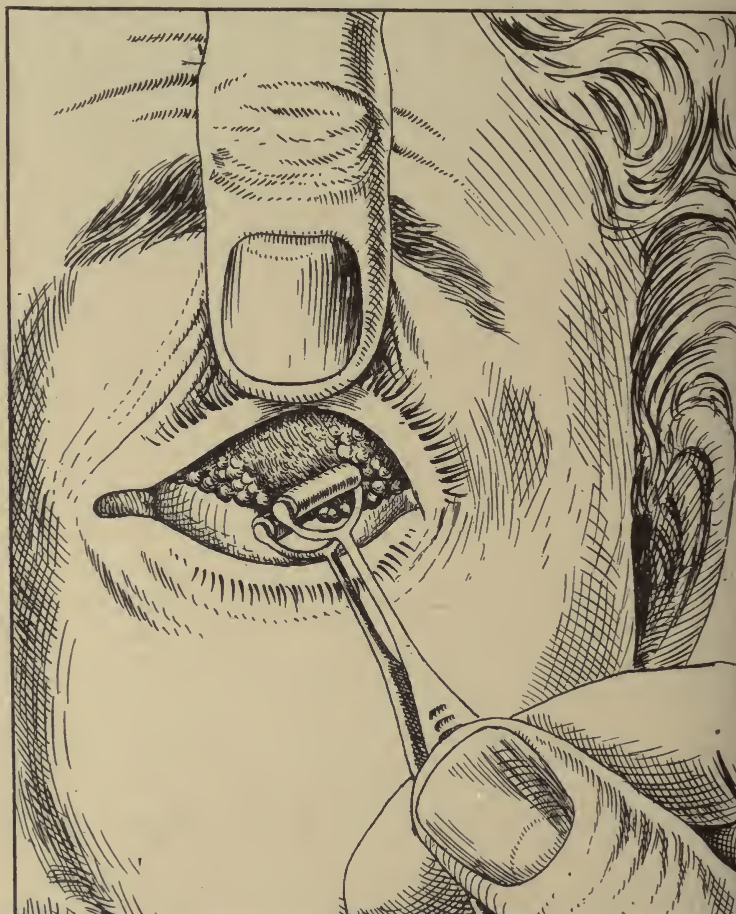

Fig. 426.
The Operation of Rolling or Expression.

conjunctiva. The forceps is now compressed with moderate force and drawn forward, so that we notice the even rolling of the cylinder that lies on the tarsal surface. The granules come out more or less crushed by the cylinders, and if they are soft their contents are seen only as a gelatinous liquid. The forceps is introduced and the manœuvre repeated again and again until all trachomatous substance is pressed out. At first the tissue caught between the rollers is thick and resistant, but gradually it thins down and, when all the infiltrated substance is out, the retrotarsal fold stretches as a thin,

doubled-up membrane between the cylinders. Then the center of the fold should be drawn up and inward so as to unfold and stretch out the portion concealed behind the outer commissure. This portion is then pressed out with the roller as thoroughly as the central portion. The same ought to be done with the lower lid and the caruncle. If, which is not rare, the tarsal surfaces of the lids are also beset with granules, these can best be pressed out if, on the lower lid, one cylinder passes over the outer and the other over the inner surface. On the upper lid this need not be done, as the longer and thicker tarsus gives sufficient resistance for the roller to liberate also the tarsal surface from the included granules. The impressions from the ridges of the cylinder give to the surface a fluted appearance which must be uniform, i. e., free from granules. On inspection the whole retrotarsal fold with the canthal portions should be entirely free from granules, and present a dark-red surface with a number of small redder dots, apparently the cavities of the granules now filled with blood. The surface may or may not be washed over with a small pad of absorbent cotton dipped in a solution of bichloride of mercury 1:500."

Ancil Martin (p. c.), a trachoma operator of wide experience, uses in the right hand a Knapp's roller forceps and in the left a Noyes'. Everting the upper lids he grasps the folds with the Noyes' and "milks" with a Knapp's. Reversing the procedure when advisable, he fixes with a Knapp's and expresses with a Noyes'. The latter method is especially satisfactory for the removal of the trachoma bodies from the canthi, and in "nursing" them from the bulbar conjunctiva. Traction should also be made from the firmer palpebral conjunctiva toward the equally separated bulbar conjunctiva and never the reverse.

After some practice one will find that he is using both hands, thus making the operation a very rapid one. Particular attention should be given to the careful removal of the bodies from the line of the folded upper lid. Should this step be overlooked, it will be discovered later that there is a transverse line of trachoma bodies along the center of the upper lid just in the situation most likely to create corneal friction.

Some operators perform linear scarification of the conjunctiva preliminary to expression.

Post-Operative Care.—If the operation is judiciously performed, there is surprisingly little reaction. Gauze pads, chilled by contact with ice, are applied to the closed lids and frequently renewed. Some operators prefer frequent douching with hot sterile water or saline solution.

The day following the operation the lids, though somewhat swollen, can be opened spontaneonsly. On eversion one observes a yellowish-grey exudate in the form of a slightly adherent pellicle covering the conjunctival surfaces. This should not be disturbed as it will come away gradually at each successive irrigation. The conjunctival surface should be copiously douched with normal saline or boric acid solution, and the lids and the margins anointed with a bland ointment.

On the second or third day a probe should be passed to the upper and lower fornices and gently drawn across from the inner to the outer angle, for the purpose of rupturing any adhesions which, if left undisturbed, would give rise to symblepharon.

D. W. White (p. c.) believes that the best preventive of symblepharon is castor oil, instilled immediately after the operation.

Various Expression Instruments for Trachoma Operations.

The mechanical principles underlying Knapp's instrument have been utilized by ingenious ophthalmologists in an effort to obviate real or fancied deficiencies.

In Campbell's modification the ends of the cylinder project beyond the ends of the shaft. Rust made one arm a straight prolongation of the shaft, the other turning off parallel with the cylinder. Both modifications were designed with the object of gaining readier access to the granulations of the external and internal canthi. Falta[10] has constructed a roller forceps, the cylinders of which are perforated,

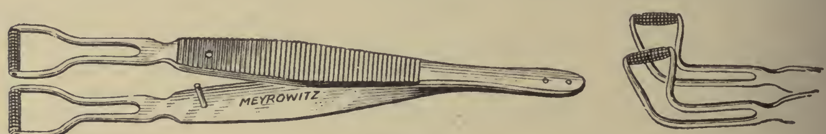

Fig. 427.
Claiborne's Roller Forceps.

the holes of one cylinder opposing a space between the holes of the other cylinders. This embodies the principles of Knapp's rollers and Kuhnt's expressors.

J. H. Claiborne's rollers have parallel rows of fine points instead of flutes. With these forceps the granulations are first lacerated and then squeezed, combining the processes of grattage and expression. Claiborne's contention (p. c.) that with this instrument the operation is attended with less trauma and insignificant post-operative reaction is, I believe, well founded. My own experience with this instrument, extending over a period of several years, has been a most happy one.

W. Norton Whitney[11] has modified Knapp's forceps by replacing one of the rollers by a "flat, wash-board like terminal, over which the remaining roller is made to pass so that the fold of conjunctiva between these two surfaces can be subjected to the necessary pressure without pulling or stretching it unduly. The motion is obtained by

[10]Falta. Trachom-Therap. in der Verseuchtesten Gegend Ungarns, Berlin, 1906.

[11]Whitney. Modified Knapp Roller for Expression in Trachoma. *Annals of Ophthal.*, Jan., 1910, p. 57.

means of a double hinge at the end farthest from the roller." This instrument was designed to obviate, to a large extent, the common defect of roller forceps, viz., the "traction exerted upon the membrane in stripping the follicles." (Beard.)

Expression forceps, in which the roller principle is not utilized, have been devised by Martin Cohen[12] and Jas. Hancock.[13] Cohen's instrument is shaped like an artery forceps having a French lock fulcrum between the blades and handles, the latter being reinforced by a removable spring. The handles are so curved as to allow for the inspection of the entire field of operation. The crushing surfaces are furnished with two horizontal grooves and are small enough to gain easy access into the canthi. A thumb rest on the posterior blade steadies the instrument while in use. The method of its application is as follows: Having everted the lids (using two of these instruments, one to steady the lid) the compression surfaces of the blades grasp the granulations, the operator being thus able to apply and control the requisite force. The advantages claimed for this instrument are: (1) The liability of injuring the conjunctiva by removing the granulations is lessened. (2) The operation is not followed by the unpleasant effects that attend the employment of other instruments, such as adhesions, inflammatory changes, granulations, and scars.

Hancock's instrument consists of opposed stationary cylinders of moderate size and absolute smoothness. It does not become clogged with blood, a fault common to most instruments of the roller type.

Simple Instrument for Expression of Trachoma Follicles.

We have considered those instruments which empty the follicles, on the principle of the mangle and those which perform their office by the combined effects of pressure and traction. There remain to be described instruments in which the principle of pressure alone is utilized. The best known is the expressor of Kuhnt,[14] with its modifications. The working part of this instrument consists of two perforated metal plates, each perforation coming in opposition with an unperforated portion of the opposite plate. The modified expressor has a perforated and unperforated plate. The modified instrument is used in gelatinous degeneration of the fornices, by inserting the perforated blade beneath the uninverted lid and making pressure.

Best Period for Expression.

Expression is most highly successful when the follicles have commenced to show softening, i. e., when the disease is entering upon its

[12]Cohen. *Phila. Med. Journ.*, Aug. 29, 1903.
[13]Hancock. A New Expression Forceps. *Med. Record*, Jan. 26, 1901.
[14]Kuhnt. *Zeitsch. f. Augenheilk.*, Oct., 1909, p. 389.

second stage. Elschnig[15] regards "expression" at this period in the development of the disease as the operation of choice. It is contraindicated in acute trachoma, in cases of follicle formation in the transition fold, during an acute exacerbation and in the cicatricial stage. The operation may require repetition one or more times. Follicles which have escaped destruction may give rise to auto-reinfection. In severely infected regions the operation does not safeguard the conjunctiva from extrinsic reinfection.

Anesthesia in Roller Operations.

In the earlier days general anesthesia was unquestionably the rule, and is still indispensable, in my opinion, in a minority of cases; e. g., excessively nervous individuals, some children, etc. Fair anesthesia is usually secured by the subconjunctival injection of a 2 per cent. cocain solution. D. W. White (p. c.) has used, with entire satisfaction, powdered cocain dusted on the palpebral conjunctiva. The operation is begun from one-and-a-half to two minutes later. He has used the method in nine hundred patients ranging in age from five to sixty years.

Although expression has received very general acceptance, it must not be imagined that the method has altogether escaped censure. An excellent summary of the principal objections that have been advanced against expression is given by Strouse[16] as follows:

"(1) The forcible expulsion of the trachoma follicles produces extensive laceration of the delicate conjunctival tissues. (2) The deeper-seated follicles are evacuated with difficulty. (3) The pressure required to eradicate the disease thoroughly, especially if, as frequently happens, the roller of the instrument does not rotate but glides over the surface, is so considerable that the underlying tissues are subjected to severe contusion which retards healing of the affected parts. In consequence of this the reproduction of normal epithelium after expression is impaired and an excess amount of cicatricial tissue is produced."

Grattage of the Conjunctiva.

Grattage is a term adopted by the French to describe a number of related procedures in which the trachomatous conjunctiva is scraped or curetted. The means employed for effecting this result are various. According to Beard[17] "scraping" is the most ancient of any of the surgical methods. (See Historical Review.) At the end of the

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[15]Elschnig. Zur Therapie des Trachoms. *Viertel-Jahreschrift. fur. die Prakt. Heilk.*, Vol. XLII, p. 73.

[16]Strouse. Grattage in the Treatment of Trachoma. *Medical News*, Jan. 11, 1906.

[17]Beard. *Ophthalmic Surgery*, 1910, p. 356.

Eighteenth century, Woolhouse, of England, "scraped" granular lids with a little brush made of barbs of grain.

Borelli[18] rubbed out the follicles with a brush made of fine metal wire.

A recent advocate of the operation is Strouse,[19] who proceeds as follows: Using a specially constructed curette, with a cutting edge 1.5 mm. wide, ground sharp in its entire circumference, the lower lid is everted and rapidly scraped over its entire extent. The upper lid is everted and held between the thumb and finger of one hand, while the curette is passed up into the fornix and this part of the conjunctival sac is scraped, care being taken to penetrate all the folds. The everted portion of the lid is treated last. During the entire procedure, which occupies but a few minutes, an assistant mops the lids with absorbent cotton dipped in bichloride solution 1 to 10,000. The surfaces are washed and touched with a 2 per cent. solution of nitrate of silver. Ice pads for half an hour. Strouse states that the advantages of grattage are an uncomplicated technique, rapidity of performance, comparative painlessness, minimum injury to the tissues, absence of inflammatory reaction after operation, simplicity of after-treatment and absence of recurrences.

Egbert[20] has devised two curettes, one sharp and one blunt, "which are so constructed that all portions of the involved conjunctiva, including the superior fornix and retrotarsal folds, can be reached and the edge is so fashioned that while all granular and hyperplastic material can be readily removed, there is little danger of injuring smooth healthy tissue. The edge of the sharp instrument points downward and backward to an angle of about 45°, and when the instrument is drawn by the handle, readily engages and removes the abnormal tissue. On the sides of the spoon the edge merges into the flat metal so as to prevent side cutting or laceration. In using these curettes the upper lid is everted over a horn or metal spatula and the sharp curette, the handle of which is held between the thumb and the first and second fingers, much as an ordinary spoon is held, with edge forward, is pushed over the eyeball well up in the superior cul-de-sac and then drawn downward from all directions of a segment of a circle, similar to that outlined by the brow. Firm, though gentle, pressure is necessary and the curetting must be thoroughly done. The blunt curette is now substituted for the sharp one and the process repeated with slightly more pressure until the tissues feel

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[18]Borelli. *Giornale d'ottalmologia Ital.*, Vol. 3, 1859.

[19]Strouse. Grattage in the Treatment of Trachoma. *Medical News*, Jan. 11, 1896.

[20]Egbert. Trachoma: Clinical Aspects and Successful Treatment. *New York Medical Journal*, March 21, 1908.

smooth under the instrument. The upturned portion of the conjunctiva is next similarly treated, the edge of the curette being turned downward. The lower lid is then likewise freed from all granules."

A highly ingenious and effective instrument for grattage is the so-called "trachomatome" devised by Jameson.[21] The following is the author's description, slightly abridged:

This instrument is planned on an observation that a pyramid of steel when placed with its apex against a mucous membrane susceptible of indentation and passed to and fro with moderate pressure will not merge in it but glide over it producing undulations. This fact applies also to numerous pyramids as represented in the instrument. This is not the case, however, should the membrane be interspersed with elevations such as exist in trachomatous membrane. As the instrument passes over the surface there is a sense of resistance and on inspection it will be found that the trachoma bodies have been attacked and ruptured, the interstices and normal tissues remaining, for the most part, intact. Jameson is confident that this instrument possesses distinct points of utility as follows:

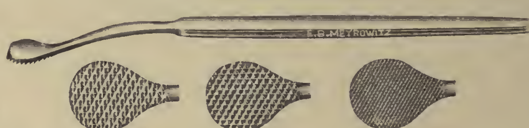

Fig. 428.
Jameson's Trachomatome.

(1) For grattage it places within reach of the operator a graded system of instruments (there are three in the set) adapted to the size of the granules or excrescences to be attacked.

(2) It is an instrument selective of granulation elements and, *per contra,* one which preserves to the greatest degree normal tissue.

(3) It is adapted not only to the primary operative, but in the post-operative treatment, in the course of which secondary growths may appear.

(4) As an adjunct to the expression operation it opens avenues in affected tissues, rendering expression easy and accomplishing it with less trauma.

In operating on the lower lid the trachomatome is placed between it and the eyeball and pressed well down against the former. Counterpressure is made by a curved index finger pressed against the lid from without. On the upper lid a double eversion is made, and having gone over the posterior exposed part the forceps are released and the everted

[21]Jameson. Report of a Different Operative Method in the Treatment of Trachoma, with Notes Upon the Construction of an Instrument Devised for the Purpose. *The Ophthalmic Record*, Feb., 1901, p. 65.

lid grattaged against the tarsal cartilage, which makes a good resistive surface. Care, however, is especially required at this step as the curve of the everted lid lies in contact with the cornea and overlaying pyramids may injure it if left unguarded. Lastly, the lid having assumed the normal position, it may be grasped between fingers, stretched, and the desired instrument swung to and fro over its entire surface.

A method of grattage and one which bids fair to enjoy extended popularity by reason of its simplicity has recently been described by Coover.[22] Under general anesthesia, the upper lid is grasped by Darier's forceps and turned to bring the retrotarsal fold into view. A horn speculum is inserted beneath the lid to protect the cornea. O or OO sandpaper, in strips 3 to 4 inches in length by ¾ of an inch in width, previously sterilized by soaking in alcohol and burning it off, is rolled lengthwise over the index finger. Holding it firmly between the finger and thumb, the entire lid surface is thoroughly and briskly rubbed. By folding or rolling the strip of paper in different ways all the recesses can be reached and the entire surface rubbed down smooth. If the lower lid is involved, it should be treated in exactly the same way. If there are any granulations on the bulbar conjunctiva, the operator need not hesitate to smooth them down also, of course using care and more gentle pressure.

The surface of the lids and entire conjunctival sac are now thoroughly cleansed of blood and adventitious sand particles. A moist dressing is applied and held in place by a light yet firm bandage. Cold applications are used for the next five or six hours and the eyes cleansed at intervals. The following day the conjunctiva will be found covered with a slight exudate which remains several days. Silver nitrate 2 grains to 1 ounce is applied once in twenty-four hours to the everted lids. After the exudate had disappeared 1 per cent. ichthyol in vaseline is used once daily, or 1 to 500 solution copper sulphate is used until the induration or thickness has disappeared, which it does in from three to four weeks.

The advantages claimed for this operation are: (1) That it is applicable to all forms of trachoma. Even in old cicatricial forms it acts beautifully, smoothing down the rough and hypertrophied portions of the conjunctiva. (2) There is very little reaction. In no cases operated on by Coover has there been a severe irritation or a single corneal complication. By this method the smaller granulations in process of development are removed and the after-treatment with caustics is unnecessary.

[22]Coover. A New Operative Procedure in the Treatment of Trachoma. *Ophthalmic Record*, Feb., 1909.

Curettage of the Trachoma Bodies According to Sattler.

The following method is enthusiastically endorsed by Sattler:[23] Under cocain (in fresh cases) or general narcosis (to insure thorough work in one sitting), the lid is everted and held by an assistant.

The follicles of the palpebral conjunctiva are punctured with a cataract needle and the contents scooped out with a sharp curette (from 1.5 to 3 mm. in diameter). To gain access to the transition fold and plica the tissue is grasped by fixation forceps and drawn to one side or the other. By shifting the grasp of the fixation forceps one is enabled to reach every part of the fold. Several seances are usually necessary.

The reaction is slight and can be readily controlled by ice compresses. A more or less prolonged after-treatment (as with expression) is necessary.

The operation is applicable to all cases with evident follicular deposits. Chronic cases with thickened lids in which the granulations of the palpebral conjunctiva and transition folds are obscured by swelling, should be subjected to preliminary medical treatment. As soon as the follicles become visible they should be "ripped and scooped." In practice, however, this method has been largely reserved for cases in which the granulations are isolated and few.

Falta[24] has recently published a highly original operation suitable for the obliteration of clumps of little follicles which are found on the convex tarsal border of the upper lid, and for smoothing out papillary overgrowths on the tarsal conjunctiva. He had made a tiny *burr, similar to a dental burr,* but with shallow grooves. This is fixed in a dental engine, the upper lid is everted, a horn plate inserted into the upper cul-de-sac, and the conjunctiva is ground smooth of papillæ and granulations by the rapidly revolving burr passed to and fro under the lid.

MASSAGE.

Massage is a term used to describe a number of closely related procedures in which the diseased conjunctiva is subjected to rubbing, with or without instrumental aid or medicaments.

Severus performed both simple and medicamentous massage.

Liekernik[25] uses glass balls, 8 to 14 mm. in diameter, mounted on handles. These are dipped in cyanide of mercury solution 1 to 2,000 and rubbed vigorously over the everted lids.

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[23]Sattler. Die Trachombehandlung, einst und jetzt. *Zeitschr. für Heilkunde.*, XII, 1891.

[24]Falta. Die Trachomtherapie in der Verseuchtesten Gegend Ungarns, 1906.

[25]Liekernik. Die mechanische Behandlung der Trachomatös-erkrankten Conjunctiva. *Centralb. für Prakt. Augenheilk.*, Feb., 1904, p. 49.

Scrini[26] dips a glass rod in a solution of iodic acid, allows it to dry and then rubs the trachomatous conjunctiva. For after-treatment he massages the cornea with cacao-butter containing dionin. Internally, iodides are administered.

Epinow[27] has devised a spoon-shaped horn plate to fit the upper conjunctival sac. This is rough on the upper surface and is inserted so as to bring the rough surface against the upper lid. The upper lid is anointed with vaseline and rubbed against this rough surface.

Herczogh[28] rubs the conjunctiva with a cotton wad saturated with a 1 per cent. sublimate solution. A similar procedure is thus described in detail by Beard:[29]

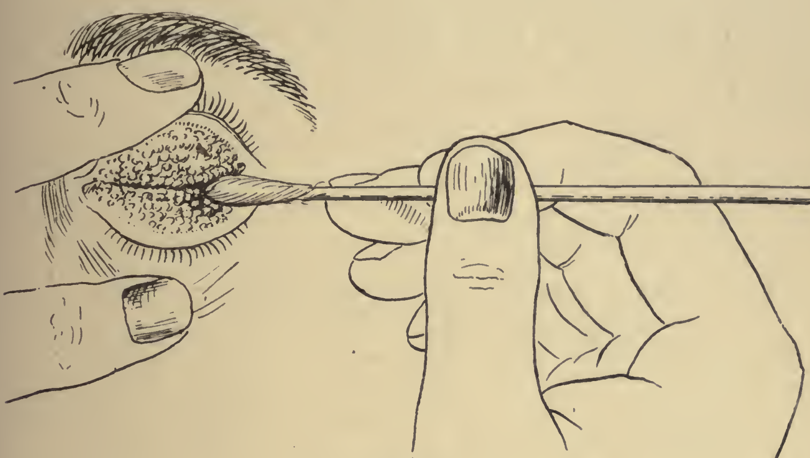

Fig. 429.
Massage of the Trachomatous Conjunctiva.

"The lids are cleansed externally with warm boric acid solution. They are then everted and a single drop of adrenalin solution put onto the conjunctiva. A small hard mop is made by winding absorbent cotton on the tip of a carrier. This is dipped into a very hot solution of sublimate, about 1 to 250 in strength, the lid is again everted and the affected conjunctiva rubbed. The rubbing should be neither too delicate nor too rough, and not prolonged beyond a minute or two, dipping the mop in the hot sublimate now and then, but never leaving an excess of liquid on it to run down over the cornea and healthy portions of the conjunctiva. Then, without replacing the lids, the whole

[26]Scrini. Ancora sulla Cura del Granuloma. *Bollet. D'Ocul.* No. 16, 1901.
[27]Epinow. Zur Behandlung des Trachoms mit Massage. *Wratsch* XVI, 1896, p. 915.
[28]Herczogh. Erfahrungen bezuglich der Behandlung des Trachoma. *Zeitschr. für Augenheilk.*, July, 1906, p. 81.
[29]Beard. *Ophthalmic Surgery*, 1910, p. 358.

mucous sac is copiously irrigated for another minute with 4 per cent. boric acid solution, as hot as can be borne. And, lastly, a drop of cocain solution is put in. This is repeated with two-day intervals, and, on the alternate days precisely the same is done excepting that a 50 per cent. solution of argyrol is substituted for the sublimate. If properly carried out, there is no irritation after either treatment."

Pratt,[30] Sedgwick[31] and Bordley[32] are firm believers in the efficacy of boric acid (in powder) well rubbed into the conjunctiva. The everted lids are vigorously scrubbed with a cotton-wound toothpick while an assistant continually dusts powdered boric acid on the conjunctival surface.

Noyes[33] everts the lids and dusts boric acid upon the conjunctiva until it is covered. The lid is then returned to position *without massage.*

Brossage.

Brossage, as the term implies, consists in "brushing out" the granulations, either with or without preliminary scarification. The method was used in the early days of surgical treatment, but fell into disuse until revived by Woolhouse at the end of the eighteenth century.

Darier's Brossage Operation.

Whatever present popularity the operation of brossage enjoys is largely due to the advocacy of Darier,[34] who has supplemented the simple "brushing out" of the follicles by a number of additional operative procedures.

If there is any reason to believe that eversion will be difficult, he begins by dividing the external angles. If the caruncle is very much involved, it is excised. Corneal pannus is curetted. The bulbar conjunctiva is then gently scrubbed with the brush, followed by lavage with sublimate. The lower lid is grasped with a special forceps (similar to a hemostatic forceps) with points on its surface for penetrating the tarsus. It is necessary to seize the lid 2 mm. from the marginal border to avoid tearing the tissues. The forceps thus placed roll the lid backward in such a manner as to stretch the conjunctiva without tearing it. All the granulations are then carefully scarified. If they are few and scattered, a bistoury or discission needle will suffice. If, on the contrary, the entire conjunctiva and the tarsal cartilage are infiltrated, Darier prefers the three-bladed knife, which renders it pos-

[30]Pratt. Treatment of Trachoma. *Ophthalmic Record*, Jan., 1906.
[31]Sedgwick. Trachoma. *Ophthalmic Record*, 1908.
[32]Bordley. Treatment of Trachoma. *Ophthalmic Record*, July, 1907.
[33]Noyes. Treatment of Trachoma with Boric Acid Powder. *Ophthalmic Record*, Oct., 1907.
[34]Darier. *Leçons de Thérapeutique Oculaire*, 1907, p. 257.

sible to make the scarifications more rapidly. The depth of the incisions should depend on the thickness of the granular infiltration, the aim being to bring to the surface the contents, while sparing the conjunctiva as much as possible. This gelatinous debris must be carefully cleaned away from the wounded surface. Then follows the "brossage," which is done with a small tooth-brush with hard and short bristles, previously disinfected by immersion in alcohol and then in a warm solution of cyanide of mercury. During the operation the brush is frequently dipped into a solution of mercury cyanid 1 to 500. One should aim to scrub just vigorously enough to empty the infiltrated tissue without bruising or tearing the little strips of conjunctiva between the scarification lines. After releasing the grasping forceps, the granulations which have been hidden by the instrument must be scarified and brushed out. The forceps are applied to the upper lid in

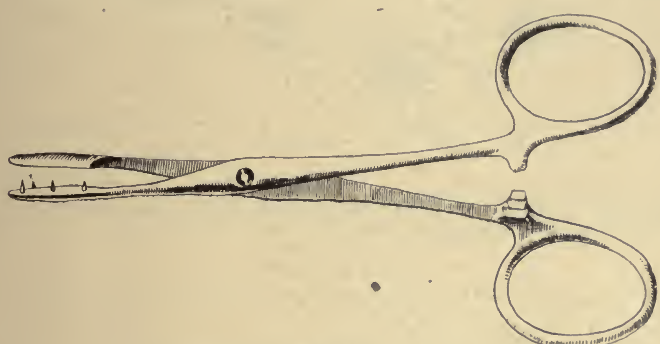

Fig. 430.
Darier's Forceps for Grasping the Lid.

a precisely similar manner and the lid rolled back. It is important to begin the scarification in the cul-de-sac because the conjunctiva, once scarified, retracts. The "brushing out" is performed as on the lower lid. The dressing consists of a cotton compress moistened with a 1 to 2,000 solution of cyanide of mercury kept on by means of a bandage. The following day the upper lid is carefully turned and gently douched, care being taken to avoid hemorrhage and to preserve the conjunctival tissue. If one cannot evert the lid a probe should be passed between the globe and the lid to prevent adhesions. The following days a 10 per cent. solution of argyrol is instilled. In a fortnight the patient is well on the road to recovery but solutions of cyanide of mercury alternating with instillations of argyrol should be kept up several months.

The *indications for brossage* are, according to Terrien,[35] (1) the

[35]Terrien. *Chirurgie de l'oeil*, 1902, p. 292-298.

presence of voluminous granulations occupying the cul-de-sac, whether associated with inflammation or not, and (2) when the infiltrated conjunctiva is being converted into waxy tissue. It has the advantage over massage that the granulations, even those hidden above the tarsus, are all reached. Improvement does not always last and repetition of the operation may be necessary. One positively unfavorable sequel is entropion, which occurred in fifteen cases out of one hundred and thirty operated on. It is probably due to too energetic brushing, which, in exceptional cases, is said to have led to the complete destruction of the conjunctiva.

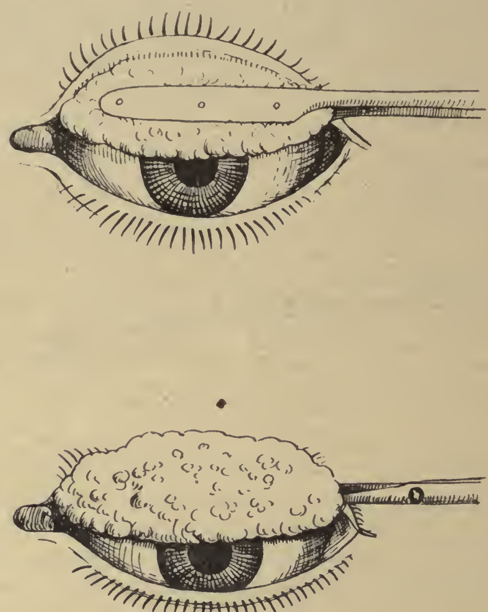

Fig. 431.
Illustrating the Use of Darier's Forceps.

THE USE OF THE CAUTERY IN THE TREATMENT OF TRACHOMA.

Thermo-cauterism of the trachomatous granulations was employed in antiquity. One can readily imagine the extensive scarring that must have resulted.

Of course, with the invention of the galvano-cautery, it became possible to limit the cauterant action (by the use of fine tips) to a tiny area. Samelsohn[36] in 1857, burned out the granulations with a very fine electrode.

[36] Samelsohn. Die Galvano-Caustik in der Ophthalmologischen Chirurgie. Graefe's *Archiv. für Ophthalm.* Vol. III, 1, 1857, p. 114.

H. Korn[37] passes a glowing platinum rod over the conjunctival surface in a manner similar to the application of a copper sulphate crystal.

Reich[38] adopted a similar method and limited the use of the cautery to early cases. The method, if cautiously employed, may be used to eradicate isolated granulations. If the follicles are numerous and generally disseminated, it will be found too tedious, requiring several seances.

Electrolysis After Preliminary Scarification.

The great drawback to galvanocauterism, as ordinarily used, is the likelihood of the subsequent development of excessive scar tissue, leading to gross deformation of the lid. Superficial cauterization fails because it does not reach the deeper lying trachomatous elements. To overcome these drawbacks, Lindsay Johnson[39] has devised a method of electrolysis after preliminary scarification. The details of this operation will be readily understood from the author's description as follows:

"The patient being placed under a general anesthetic * * * * * * * * * * the upper lid is everted over the end of the vulcanite spatula

Fig. 432.
Hook for Holding Eyelid when Everted. (Lindsay Johnson.)

(Fig. 434), and the conjunctiva kept tightly stretched over it by means of the double hook (Fig. 432).

This should be inserted close to the free edge of the mucous membrane of the eyelid. * * * * * * * The hook and spatula should now be firmly held between the finger and thumb of the left hand, while the three bladed scalpel, or 'sillonneur' (Fig. 435) is taken in the right hand. This should be held tightly like a pen, and the movable guard adjusted to a distance of 2 mm., 3 mm. or 4 mm. from the tip, according to the looseness of the conjunctiva, the edema of the papillæ, and the general appearance of the lid—in other words, the more succulent the mucosa, or the larger and thicker the papillæ, and the more swollen and congested the parts generally, the deeper must be the incision. * * * * * * * The incisions are best made parallel to the edge of the lid in a gentle curve, the first incision being made close to the edge and the others following in regular succession towards the retrotarsal fold. See Fig. 433. About fifty small tufts of absorbent cotton-wool, previously dipped in an aqueous solution of boric acid or hydronaphthol 1:100, and then squeezed nearly dry, to be kept in readiness by the assistant, who should rapidly mop up the blood in the track of the sillonneur (3-bladed scalpel).

"Having made a complete cut from corner to corner with the sillonneur,

[37]Korn. *Berl. Klin. Wochenschr.*, 1870, p. 201.

[38]Reich. Galvano-Caustik bei Conjunctivitis follicularis. *Klin. Monatsbl. f. Augenheilk.* 1888, p. 56.

[39]Lindsay Johnson. A New Treatment for Chronic Trachoma. Knapp's *Archives of Ophthalm.*, Vol. XIX, 1890, p. 264.

the next incision must be made in the track of the first, i. e., the first blade of the sillonneur must run in the groove made by the third blade of the previous cut. The cuts must be made by a finger and not by hand motion, otherwise the cuts will not reach the further side of the lid. * * * * * * * After several cuts have been made in this way, the hook must be released and reinserted farther away from the free edge, so as to put the swollen retrotarsal fold on the stretch. The cuts are to be continued several times in this manner, and the hook is to be reinserted at the posterior border of the cartilage, so as to get the whole of the retrotarsal fold over the end of the spatula; by this means the whole of the conjunctiva nearly up to the bulb can be incised. The bleeding is sometimes

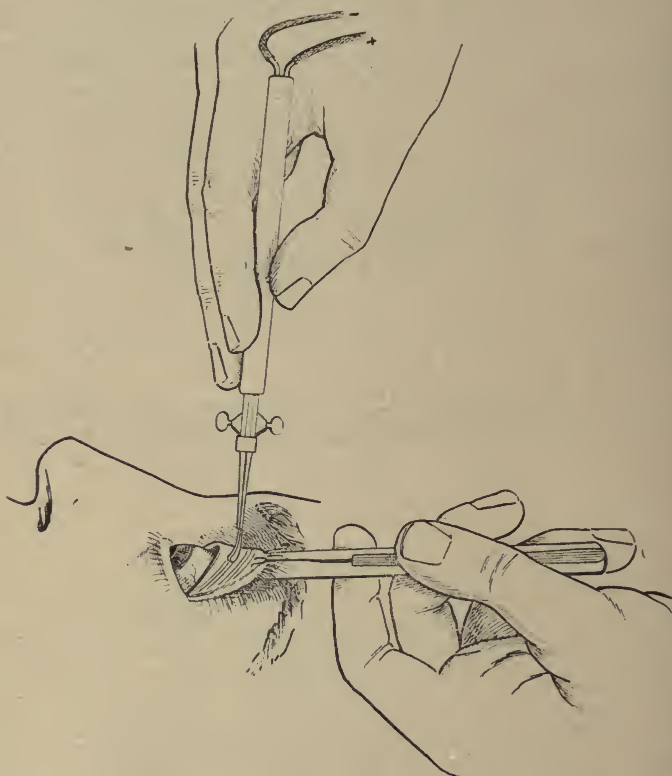

Fig. 433.
Horn or Celluloid Spatula, Laid on the Upper (or Lower) Rim of the Orbit, the Everted Lid Over it and Held by the Double Hook.
(Lindsay Johnson.)

excessive, but can always be controlled by firm pressure with the cotton pads on the conjunctiva.

"It is generally advisable to operate on both upper lids one day and both lower lids a few days later, as it is rare to find only one eye affected, and were both lids of one eye operated on the same day the inflammation set up might be excessive.

"This part of the operation ought not to take more than three minutes for each lid.

"*Second stage*, (see Fig. 433). The spatula being held under the everted lid as before, and the hook reinserted in its first position near the free margin, the electrolyser (Figs. 433 and 437) is now connected by

wires with a battery. I have always used a Stöhrer's carbon and zinc battery of twenty cells. The instrument being held in the right hand, the lower edges of the two platinum blades are pressed firmly in the first two grooves made by the sillonneur and very slowly drawn along the furrows from end to end. About four or six cells (equal about thirty milliamperes) are used, and if in good working order the result will be at once seen by the thick foamy cream which rises round the blades. This is due to bubbles of hydrogen which are given off at the terminals (the platinum blades), and which, mixing with the blood and exudation, form the yellowish-looking froth. All the grooves are taken in turn, being slowly opened up along the lid from end to end.

"Frequently the spatula will have to be shifted to enable the lid to be put well on the stretch and to allow of the platinum blades reaching well into the corners. The foam all the time must be rapidly and repeatedly sponged away, and especially from around and between the blades. This stage of the operation takes about eight or nine minutes for each lid, as the blades have to be drawn through all the furrows very slowly from the free edge of the lid to the last incision made with the knife. It will be found that the electrolytic action tends to stop the bleeding rapidly, so no fear of after hemorrhage need be entertained.

" * * * * * * * Strong electrolytic currents should be avoided.

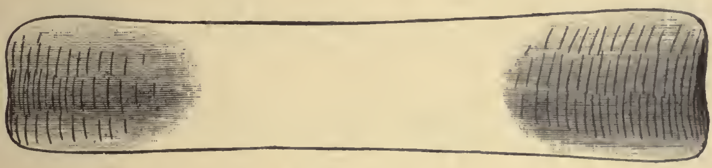

Fig. 434.

Spatula Curved so as to Rest Against the Upper Surface of the Lid.

* * * * * * * I have found that from four to six cells give the most satisfactory results.

"Should the retrotarsal fold be very loose and much thickened, it may at this juncture be found advisable to dissect out a narrow strip of conjunctiva along the whole length of the fold. This may be hooked up by means of Galezowski's double forceps, or the ordinary fixation forceps. * * * * * * * Unless the conjunctiva be very loose, it is best not to remove the strip of conjunctiva, or at least only to remove a very narrow one—1 mm. or 1½ mm.—else too much of the fold may be picked up, and the movements of the eye ball, if not limited, at any rate slightly disfigured by an ugly fold, when the eyes are rolled upwards. This of course, can only happen in the case of the lower lid, as the upper one overlaps too much to render any fold visible without everting the lid. But in the majority of cases the incisions made with the sillonneur will be found to do all that is necessary both for opening up the hiding-places of the follicles which crowd the recesses of the fold, and for cutting off the supply of blood from the vessels which help to produce the pannus. I have rarely found it necessary to cut this strip away from the lower lid, and I now only use it exceptionally in the case of the upper one.

"*Last stage of the operation.* Both lids are now washed free from blood, sprinkled with a 5 per cent cocain solution and dusted with calomel. Finally they are smeared over with an ointment made of vaseline and hydronaphthol, 1 to 800, and the eye bandaged up with thick, moistened compresses. Should the inflammation during the next twenty-four hours be at all severe, which may be judged by the swelling of the eyelids, I order ice compresses to be applied and frequently changed."

"For forty-eight hours the discharge from the lids is often considerable and many of the follicles slough out, but between the second and third day a decided change for the better sets in and the wounds rapidly heal.

"Formerly I found it necessary to repeat the operation on both upper

Fig. 435.
Three-bladed Knife for Making Incisions Across the Lid in Parallel Cuts, each 1 mm. Apart.

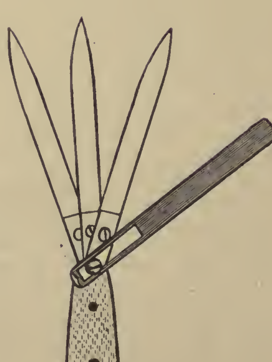

Fig. 436.
Blades Spread Apart to Clean.

Fig. 437.
Sillonneur, or Plough, which takes the 20 or 25 milliampere current. The terminals are two blunt platinum blades which are caused to pass slowly up and down the grooves. The electrolytic action decomposes the tissues without charring them, or only slightly, preventing the wounds from healing by first intention, thus allowing the follicles to escape with the pus.

a. Two Blades Open to Cleanse.

and lower lids but by using a weaker current, and the same time using the platinum blades more thoroughly and systematically, I have found one operation quite sufficient.

"As soon as the wounds have healed up I wash the lids with a hot boric lotion each day, afterwards smearing them over with vaseline or hydronaphthol ointment, 1:800. This should be continued for at least three weeks. It is not necessary to keep the patient in bed during the treatment. * * * * Great care should be taken not to touch the cornea during the operation, as rather severe ulcers and abscesses may ensue by neglecting this."

Electrolysis Alone in the Treatment of Trachoma.

Ombini[40] is said to have been the first to use electrolysis in the treatment of trachoma. The method has some very enthusiastic advocates, among whom may be mentioned Malgat,[41] Coppez[42] and Myers.[43] The latter everts the lids and applies 4 per cent. cocain directly to the point he intends to attack. An extremely sensitive granulation is anesthetized by applying the solid drug directly to it. With a current of 1½ to 2 milliamperes, a very delicate platinum electrode is plunged into the granulation, withdrawn and the coagulated material washed away with a saturated solution of boric acid. The seances are repeated until all the granules have been similarly attacked.

Fig. 438.
Handle to Hold the Blades When They are Sharpened.

Pansier[44] has obtained improvement, but never permanent cures by this method.

Margaret A. Cleaves[45] states that thirty-seven applications of zinc electrolysis (2½ milliamperes) for two minutes at each sitting, cured a case of neglected trachoma; improvement was noticed in ten days.

X-Ray Treatment of Trachoma.

The use of the X-ray in the treatment of trachoma was first reported by Mayou.[46] He was led to experiment with radiotherapy in

[40]Ombini. La Galvano-caustique. Chimique dans le Traitement de la Conjunctivite Granuleuse. *Gazetta Medica Italian*, 1877.

[41]Malgat. Du traitement des granulations conjunctivales par l'Electrolyse. *Recueil d'Ophtalmologie*, Feb., 1895.

[42]Coppez. Behandlung des Granulation mit Electrolyse. *Beilageheft zur Zeitsch. für Augenheilk*, II, 1899, p. 78.

[43]Myers. *The Treatment of Chronic Granulations of the Eyelids by Electrolytic Action*, 1891.

[44]Pansier. *Traité d'Electro-thérapie oculaire*, 1896.

[45]Cleaves. *Trans. Am. Electro-Ther. Assn.*, Sept., 1903.

[46]Mayou. A Case of Trachoma Treated by X-Rays. *Ophthalmic Review*, July, 1902, p. 203.

this disease by the following considerations:[47] The efficacy of the treatment by caustics is due partly to the production of a leucocytosis with subsequent cicatrization of the trachomatous nodules, partly to the mechanical removal of the diseased tissues, and the destruction of the specific causative agent. Caustics possess the disadvantage of partially destroying the normal palpebral epithelium, thus increasing the tendency to scar formation. The X-ray is an agent capable of producing a more or less prolonged leucocytosis from the mildest to the intensest grade without (except under ill-regulated exposures) seriously impairing the integrity of normal epithelium. Theoretically, therefore, it should exercise a most favorable effect on trachomatous tissue.

Judging from the surprisingly rapid and complete cure in this and subsequent cases, it must be admitted that Mayou's theoretical contentions have been borne out by the results of treatment. The technique of the application is described as follows: The upper lid being everted, the lower is pushed up so as to cover the cornea (in pannus the cornea is left exposed). The patient is seated nine inches

Fig. 439.
Metal Head Fixed to the Battery Wires to Decompose Corners which the Plough Cannot Easily Reach.

from the anode of a moderately-soft tube and is given daily sittings for four to six days, followed by a week's rest. Should there be no reaction the sittings are continued twice a week until the appearance of photophobia which indicates beginning reaction. Shortly after the trachoma bodies begin to disappear. Sittings are continued once or twice a week until the masses are no longer visible. A certain amount of injection of the conjunctiva persists for several weeks after cessation of treatment and it is not possible to tell whether all masses have disappeared until this has subsided. Pannus disappears rapidly and old opacities and corneal scars clear up surprisingly.

The cases best suited for treatment are those of the ordinary chronic type. Acute cases exhibiting diffuse infiltrations with much photophobia require very careful management and are not so favorably influenced. In the end the conjunctiva is left free from scars and uncontracted. The following positive advantages are claimed: (1) The cure is effected with a minimum deformity of the lid; (2)

[47]J. Green, Jr. The Treatment of Certain External Diseases of the Eye by X-Rays. *Interstate Medical Journ.*, Vol. XI, No. 6, 1904.

the treatment is painless; (3) pannus clears with unexampled rapidity.

Mayou's results have been confirmed by a number of observers, notably by Stephenson and Walsh.[48] In four cases of severe bilateral trachoma these authors subjected one eye only to the X-ray, the fellow (or "control" eye) being either untreated or treated by ordinary methods. Two cases were absolutely cured, the other two showed marked improvement, while in all the "control" eyes remained *in statu quo*. In the same paper the authors report the complete cure of a severe case of trachoma by the application of a mild high frequency brush by means of a vulcanite electrode. This interesting result led them to advance the suggestion "that the common agency may be a brush discharge visible from a high frequency electrode, but invisible from the focus tube.

The two methods have been combined by Geyser,[49] who reports eighteen cases successfully treated. "After six to eight exposures to the X-ray, the treatment is continued by the direct application to the conjunctiva of a high frequency vacuum electrode, for from one to three weeks."

A more recent experience is that of Basutinsky,[50] who made a study of the effect of radiation in trachoma, subjecting one eye to the influence of the rays, while the other, protected by lead screens, was used for comparison. The treatment comprised sixteen seances of five to six minutes' duration covering a period of two and one-half months.

On the basis of results one month after the last seance, Basutinsky states that (1) The infiltration was diminished, and pannus was improved; (2) the trachoma follicles were still present; (3) there was no complete cure; (4) there was little tendency to scarring; (5) the method was painless and may be used where other means are contraindicated.

It may be stated, parenthetically, that MacCallan, than whom no one is in a better position to judge, has not been encouraged by good results to continue the use of the method.

Radium Treatment of Trachoma.

Comparatively few workers have applied radium to the treatment of trachoma and their testimony as to its value is inconclusive. Jacoby[51] states that radium has unmistakable therapeutic action. Falta *(loco cit.)* passed a glass tube containing radium bromide to and fro across the conjunctiva for ten minutes daily. The trachomatous bodies disappeared in from one to two weeks but the conjunctival infiltration

[48]Stephenson. *Medical Press & Circular*, 1903, p. 77.
[49]Geyser. *Journ. of Advanced Therapeutics*, May, 1904.
[50]Basutinsky. Die Roentgentherapie bei Trachom, *Vratsch.*, p. 12, 1905.
[51]Jacoby. Zur Radiumbehandlung des Trachoms. *Deutsch. Med. Woch.* Vol. XXXII, No. 2, 1906.

lasted much longer. There appears to be no danger to sight and the method, which is painless, can be used indefinitely at discretion.

Muschelow[52] used radium in thirty-two cases and concludes that: (1) In old cases it has very slight effect. (2) The follicular type of the disease is benefited with no scars resulting. (3) Recurrences were not observed (the author admits that the period of observation was too short to permit of final conclusions on this point). (4) The method is painless and not dangerous.

Birch-Hirschfeld[53] states that although the treatment brings about a smoothing and disappearance of the follicles, recurrences were almost invariably observed, and other therapeutic methods were necessary to complete the cure.

Excision of Conjunctiva in the Treatment of Trachoma.

Doubtless most ophthalmic surgeons will agree that practically all of the surgical procedures described above have in common the serious drawback that *they do not insure against relapses,* even when followed by prolonged after-treatment. And the reason for this is not far to seek. The seat of predilection for the trachoma follicles is the upper fornix. Hidden in folds of conjunctiva and deeply recessed, they are difficult to reach by any form of surgical attack. Expression, brossage, scarification, etc., may succeed in ridding the conjunctiva of much of the offending material, but here and there, remain follicles that have escaped. It is these that are responsible for the auto-reinfection.

A realization of the inefficacy of surgical measures which had for their object the eradication of the individual follicle led Benedict, in 1822, to advocate the bodily removal of the trachoma-bearing upper conjunctival fold. It appears that this suggestion received little or no support and the practice fell into disuse, until revived by Galezowski[54] in 1874.

The technique of the operation is as follows: The lid having been everted, one blade of Galezowski's double-pointed tooth forceps is passed into the cul-de-sac. The teeth are engaged in a fold of conjunctiva which is drawn downward and the forceps are closed over it, thus giving control of the operative area. A piece of conjunctiva 3 to 8 mm. wide and as long as the fornix is excised by scissors dissection. No sutures.

Galezowski was well satisfied with the results of excision, both

[52]Muschelow. Bequerrelstrahlen bei Trachom. *Westnik. Ophth.*, p. 530. 1907.

[53]Birch-Hirschfeld. Klinisch und Anatomische-Untersuchungen Ueber die Wirkung des Radiums auf die trachomatöse Bindehaut. *Klin. Monatsbl. für Augenhlk.*, XLIII, Vol. 2, p. 497.

[54]Galezowski. *Recueil d'Ophtalm.*, 1874, p. 134.

immediate and remote, especially as it offered a partial immunity against recurrences. The operation, though correct in principle, was, incomplete, for no account was made of the subjacent tarsus which was usually seriously compromised.

It remained for Heisrath[55] to supplement the Galezowski operation by excising a strip of tarsus along with the fold of conjunctiva. This device marked a tremendous advance in the operative treatment of certain intractable cases of chronic trachoma, and developed and modified by Vossius[56] and Kuhnt[57] it has proved of inestimable service in a class of cases once the despair of victim and surgeon alike. Kuhnt, practising in a district (Koenigsberg) where trachoma is endemic, had ample opportunity to put into application the modifications of Heisrath's procedure suggested by experience, and to determine the indications and limitations thereof. Three closely related procedures are the outcome of this experience. They are: (1) Simple excision of a strip of infiltrated fornix. (2) Combined excision, i. e., removal of a part of the tarsus together with a strip of infiltrated fornix (chiefly applicable to the upper lid). (3) Extirpation of the tarsus.

Simple excision is almost invariably performed on the lower fornix. Its indications are, according to Beard:[58] First: When other methods have failed, or when there are relapses. Second: When the tarsus or the bulbar conjunctiva are becoming involved. Third: When there are corneal complications. Fourth: When the patient comes from a trachomatous district and will go back to it. The operation is contra-indicated when the conjunctiva is at all scant.

Technique.—One method of performing this little operation is as follows: The point of a hypodermic syringe (filled with a 4 per cent. solution of cocaine) is thrust horizontally into a fold of conjunctiva (seized and raised near the outer commissure) and advanced the whole length of the lower fornix. In withdrawing the syringe 4 minims are injected into the subconjunctival tissue. This artificial edema renders the granules in the folds very conspicuous. With the fold stretched by an assistant the operator circumcises it with a scalpel. The end of the fold is held up with forceps and the whole strip excised with scissors. Sutures are usually omitted.

Combined Excision.

Combined excision is, to all intents and purposes, Heisrath's orig-

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[55]Heisrath. Uber die Behandlung der Granulom. Bindehaut-Entzündung. *Berlin. Klin. Wochenschr.*, 28, 29, 30, 1882.

[56]Vossius. Zur Operativer Behandlung der conjunctivitis granulosa durch Excision. *Bericht der Ophthalm. Gesell.*, 1884, p. 186.

[57]Kuhnt. Uber die Therapie der Conjunctivitis Granulosa. *Klin. Jahrbuch.* 1897, p. 413.

[58]Beard. *Ophthalmic Surgery*, 1910, p. 363.

inal procedure. It has attained great popularity in Germany, largely through the enthusiastic advocacy of Kuhnt, but strange to say has failed to receive an equivalent appreciation in this country.

Nevertheless, the operation has had enthusiastic supporters in the United States, notably Casey Wood[59, 60] and Frank Brawley,[61] who have given us clear and detailed descriptions of the various steps of the procedure. The following excerpt (from Casey Wood's second paper) will give the reader an adequate conception of this highly important procedure:

"When the operation is done, as it usually is, on the upper lid, the latter is everted so that the convex border of the tarsus is thoroughly exposed. This is now firmly grasped by two strong, toothed forceps at the junction

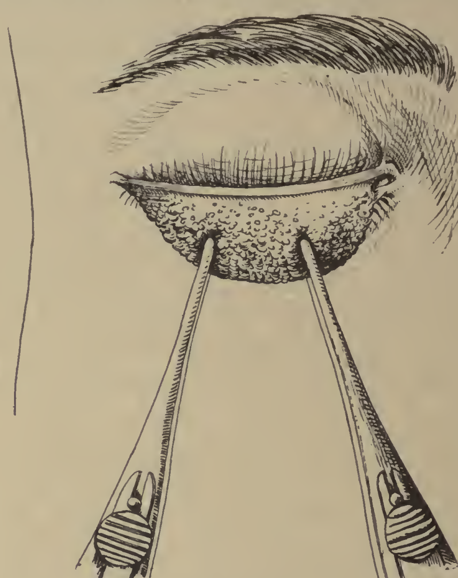

Fig. 440.
Excision of the Tarsus.
First Act. Eversion of the upper lid with forceps (Kuhnt).

of the middle with the outer and inner thirds of the tarsal margin, and drawn firmly upward by the assistant standing at the patient's head. The junction of the palpebral and ocular conjunctiva is now fully exposed and may be readily examined. Following as nearly as possible the margin of the diseased area, an incision is made from the outer to the inner canthus through the conjunctiva only. Unless, in consequence of previous mechanical treatment, the conjunctiva is bound down to the underlying tissues, the wound will gape and the fibres of Mueller's muscle may be recognized.

[59]Casey Wood. Removal of the Tarsus and Retrotarsal Folds in Certain Cases of Chronic Trachoma. *Annals of Ophthalm.*, 1898, p. 372.

[60]Casey Wood. Exsection of the so-called Tarsal Cartilage in Cases of Chronic Trachoma. *Amer. Journ. of Ophthalm.*, July, 1903.

[61]Brawley. Trachoma as Treated by Kuhnt. *Ophthalmic Record*, Oct., 1905.

Three stitches should now be passed through the bulbar margin of the incision, care being taken to include only the conjunctiva and a few fibres of the submucosa. If more than a mm. in width of conjunctiva is included in the sutures, small symblepharon folds may form opposite each stitch, and if too deeply inserted there will be a noticeable dragging on the lid edges, as occurred in one of my own early attempts.

"A word as to the sutures. My assistant, Frank Brawley, has prepared for me a modification of the black silk (preferably No. 2 black braided) which Worth advises in his advancement operations. I have used them for the past year with great satisfaction in all operations that involve the conjunctiva and I warmly advocate their employment in the procedure about to be described. The silk is first wound upon ordinary glass microscopic slides (for convenience of handling) and sterilized by boiling thirty minutes. It is then dehydrated by immersion in absolute alcohol for ten minutes and the drying process assisted by holding the slides a few feet above

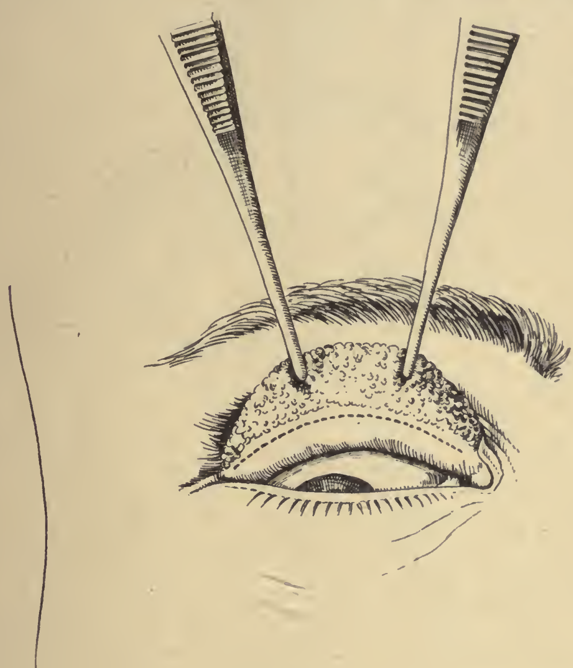

Fig. 441.

Excision of the Tarsus.

Second Act. Complete Eversion of the Upper Lid and Exposure of the Retrotarsal Folds. First incision along the dotted lines (Kuhnt).

a Bunsen burner flame for a few additional minutes. The slides of silk are then dropped into a jar of paraffin containing 25 per cent. of vaseline, where they remain until used. Each time they are used the jar containing the silk is resterilized by heating, an end of suture is drawn out of the jar and the excess of wax is "stripped" off the required suture lengths by drawing it through sterile gauze held between the thumb and finger. The threads are now somewhat stiff yet flexible, are easily threaded, never "kink" and slip through the tissues with the minimum amount of friction and traumatism and do not readily tear out of the tissues in which they are placed. Moreover, knots made in these threads are much less likely to irritate and abrade the cornea or bulbar conjunctiva. Once introduced through the lower wound margin they should be allowed to hang down

over the globe (see diagram) and to rest on a sterilized towel placed on the cheek. After the sutures have been thus placed the bulbar conjunctiva should be separated from the globe a distance of 3 to 5 mm. from the edge of the wound. The forceps may now be removed from the convex border of the tarsus and the lid margin be grasped at its middle point, a horn spatula being passed behind the everted lid, as shown in the diagram. A second incision, running the whole length of and parallel to the lid edge, is now made as nearly as possible in the healthy conjunctiva. Sometimes this will be three, sometimes even five mm. from the palpebral border, the intention being to remove as little of the unaffected mucous membrane as possible and so to leave as large a portion of the central conjunctival area as is consistent with the needs of the case. The spatula may now be removed, the assistant drawing the lid upward and backward with one or two fixation forceps. The operator then seizes the tissues at the nasal

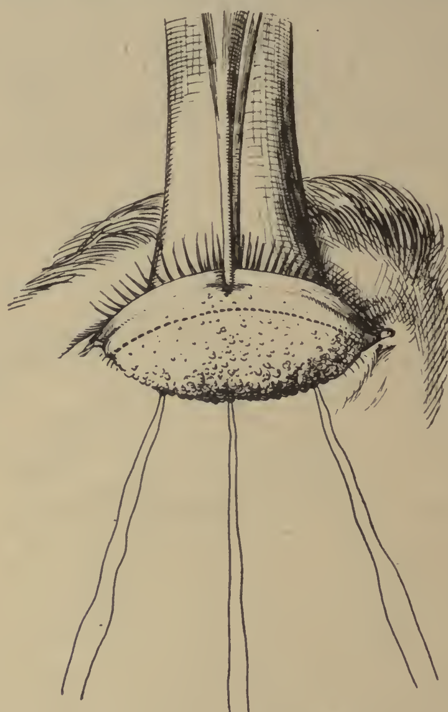

Fig. 442.
Excision of the Tarsus.
Third Act. Second incision near the lid margin, after placing of the sutures in the upper border of the first wound (Kuhnt).

junction of the two incisions and with scalpel and scissors slowly excises conjunctiva and tarsus, carefully avoiding the orbicularis and Mueller's muscle. At this point the anesthetic may be removed, and the time allowed for the bleeding to cease. I have not been much troubled with hemorrhage; although some small branches of the arterial supply may have to be twisted.

"The conjunctival sac should be thoroughly irrigated and the lips of the wound brought together. To secure a satisfactory result one must be particular to place each suture in both wound margins so that it will exactly oppose its fellow when the eye is closed. It is also requisite that the bulbar conjunctiva should not be too much put upon the stretch. The middle suture should first of all be tied with a single knot and it is wise to make

certain, by closing the lid, to ascertain whether the precaution just mentioned has been taken before the final knot is tied. I would advise the operator to allow the patient to recover from the anesthetic sufficiently to enable him to determine accurately whether the palpebral movements are sufficient and to be sure that there is no irregularity visible at the lid margins. If the interpalpebral space is the same, both with the eye open and shut as it is on the opposite side, and if the lid margins have a regular outline, all is well and the threads may be cut off close to the knots.

"As a rule there is little subsequent pain, and very little reaction. The after-treatment is simple and need not interfere with the attention properly demanded by the presence of corneal ulcer or other complications. On the whole I find gentle irrigation of the sac four or five times daily with warm boric acid solution, followed by the instillation of warmed and sterile vaseline, is grateful to the patient and acts very nicely. The vaseline keeps the sutures soft and serves to protect the cornea. I apply a light bandage

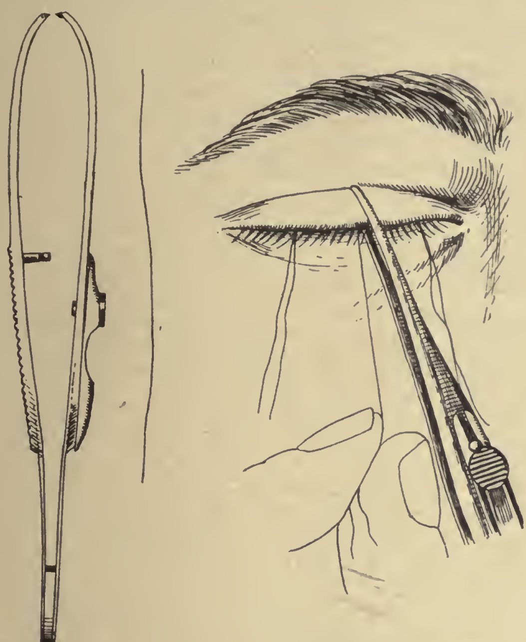

Fig. 443.
Excision of the Tarsus.
Fourth Act. Bringing the edge of the wound together after tarsal excision. Estimating the proper place to enter the needles below. Forceps used in operation (Kuhnt).

over both eyes and order the patient to keep quiet, but do not insist upon his remaining in bed. The sutures are removed on the fourth or fifth day. In a week or ten days the wound is usually quite healed but the sac should be subsequently examined for the presence of granulation tissue or irregular wound margins. These are best clipped off or trimmed with scissors."

The indications for the combined operation are: (1) Long standing cases "in which the lids show trachomatous infiltration, with granulation deposits in the connective tissue of the retrotarsal folds, whether the cornea be affected or not." (Wood.) (2) Thickening and enlargement of the tarsus. (3) Disease of the folds with corneal com-

plications but without involvement of the tarsus. (4) Deep-seated foci in the tarsus remaining after the cure of granulations in the tarsal folds.

The contra-indications are: (1) Recent cases. (2) Cases which promise definite cure by less radical measures. (3) Cicatricial cases. (4) Cases with a tendency to xerosis of the conjunctiva.

Modifications of Combined Excision.

One of the most difficult features of the operation is the proper placing of the sutures. To facilitate this step slight modifications have been proposed.

Falta *(loco cit.)* inserts each suture in the upper wound margin, as soon as the dissection of the tarsus has reached a point opposite the site of the suture in the lower wound margin, thus getting his sutures in position before the anatomical relations are disturbed. After tying, the stitches are left with long ends and are affixed by adhesive tape to the temples. On the fourth day the stitches are gently pulled out without everting the lids. To avoid abrasion of the cornea by sutures and to prevent entropion, Cahn[62] passes doubly armed sutures through the lid and ties them on the skin surface. Gronbähn[63] inserts a continuous suture and ties it on the skin over a roll of cotton.

Blascovics[64] introduces doubly armed sutures upon the inner surface of the lid above the incision, passes them through the thickness of the lid emerging on the skin surface and ties.

Beard[65] has suggested a number of modifications. He makes the incision in the tarsus slanting upward instead of perpendicular to the plane of that body, thus securing "less unevenness in the resulting cicatrix." To avoid contact of the knots of the middle sutures with the cornea, five double-armed sutures are introduced as follows: "One needle passes through the flap of conjunctiva from the epithelial side, then through the remnant of tarsus, coming out at the free border almost in line with the cilia. The other needle is made to pass through the tarsus in a similar manner, but slightly in front and to one side of the track of the first needle. The two ends of thread are tied over a long slender cylinder of gauze. The two outer sutures are knotted in the usual way, i. e., on the conjunctival surface. Addario[66] removes the upper two-thirds of the tarsal mucosa, and upper third of the tarsus and transplants healthy conjunctiva from the eyeball to fill the gap.

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[62]Cahn. Zur Excision der Uebergangsfalte. *Centralb. für Prakt. Augenheilk*, Dec., 1898, p. 369.
[63]Gronbähn. *Tidskrift for den Nordske laegeforming*, 1907, p. 829.
[64]Blascovics. Ueber Bindehaut-und Tarsus-excisionen bei Trachom, *Zeitschr. für Augenheilk.*, May, 1906, p. 391.
[65]Beard. *Ophthalmic Surgery*, 1910, p. 365.
[66]Addario. *Arch. di Ottalm.*, July, 1908.

Bitzos[67] excises the diseased part of the tarsus, scarifies the posterior surface and transplants it with the posterior surface turned to the front.

Various objections to these operations have been advanced largely on theoretical considerations. It has been contended that contraction of the conjunctiva, the usual sequel of a trachoma that has run its course, would be promoted. It is true that irregular folds in the region of the sulci, limiting ocular excursions, have been observed, but only when sutures have been improperly placed. The possibility of ptosis from destruction of the levator nerve endings has also been urged as an objection. As matter of fact, owing to relief from spasm of the orbicularis, the palpebral aperture is appreciably wider

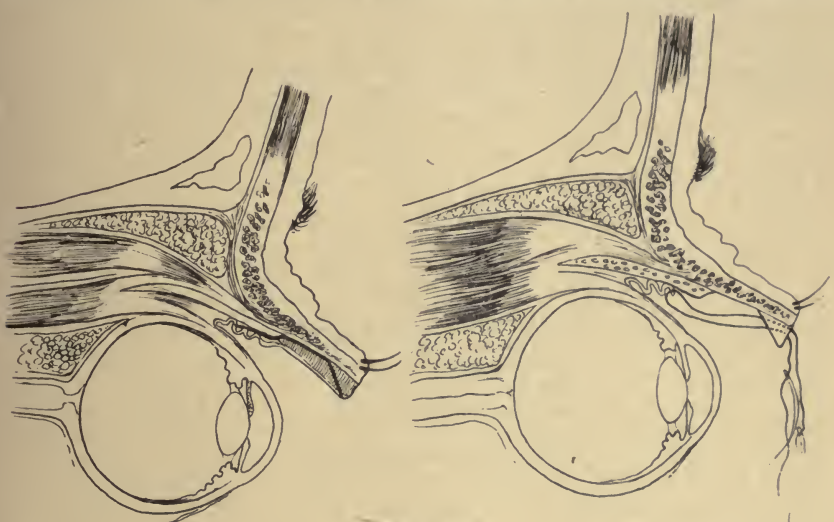

Fig. 444.
Modifications of Combined Excision (Beard).

after the operation. The removal of much of the incurving tarsus has a decided tendency to restore the lid margin to its normal position. Entropion, therefore, need not be feared. It is possible that corneal ulcers may have occurred through rubbing of the sutures. This is a danger that can be readily avoided by modified suturing as described above.

"The most important result of this operation is the relief given to the irritative symptoms of the disease. Very shortly after the removal of the stitches we notice the subsidence of the photophobia, the lachrymation, the foreign body sensations, and the local discomfort that accompany chronic granular lids, even when there is no ulceration of

[67]Bitzos. *Jahr. f. Ophthalm.*, 1899, p. 402.

the cornea or no acute conjunctivitis present. Pannus is always lessened and may even disappear, and as a direct consequence of this the sight is much improved. In one very severe case of corneal infiltration, referred to in my previous communications, where the visual acuity had fallen to 1/10 it rose to 2/7 within three months after the tarsal excision. The asthenopia generally exhibited in the better eye of a case of chronic unilateral trachoma is wonderfully improved, and, strange to say, in not a few cases those common sequels of chronic trachoma, entropion and trichiasis are decidedly less marked than before the operation. Finally, when we have to deal with recurrent ulcer of the cornea, a cure of the abnormal conditions behind it generally prevents a return of the disease." (Casey Wood).

The combined excision is, in Kuhnt's estimation, the best prophylactic against pannus.

Extirpation of the Tarsus without Sacrifice of the Conjunctiva.

This operation was devised by Kuhnt for cicatricial cases in which the conjunctiva was free from disease and overlay a thickened, infiltrated tarsus. Such cases are very prone to develop pannus and mechanical ptosis. The extirpation of incurved tarsi has also been found efficient as a relief from entropion.

The operation is thus described by Beard:[68]

"An assistant grasps the margin of the lid with the Blomer forceps, everts it, and places beneath the now inverted tarsus the Jäger spatula. The operator makes an incision through, and the whole length of the tarsus, 2½ mm. from the free border, taking care not to wound the fascia underlying the orbicularis. The conjunctiva is dissected from the tarsus, leaving the latter exposed. The cartilage is then separated from the pretarsal connective tissue up to the convex border by means of blunt pointed scissors, and, lastly it is detached from the levator tendon. As a rule, sutures are not required. The after-treatment is the same as for the combined excision."

Subconjunctival Injections in the Treatment of Trachoma.

It is not surprising that trachoma should have been subjected to subconjunctival medication, despite the fact that the rationale of the treatment is not obvious.

Ziklossy[69] highly extols subconjunctival sublimate injections in acute trachoma as a means of terminating pannus. It is of no avail in old pannus where there are no signs of acute infiltration.

Santos-Fernandenz[70] reports five cases of trachoma in which he

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[68]Beard. *Ophthalmic Surgery*, 1910, p. 367-8.

[69]Ziklossy. Die subconjunctival Sublimat Einspritzungen in der Behandlung des trachomatösen Pannus. *Pester Med. Chirurg. Presse* No. 50, 1-2, 1895.

[70]Santos-Fernandenz. Injections Sous-Conjunctivales de permanganate de potasse dans le cul-de-sac contre le trachome. *Révue gén. d'Ophtalm.*, 1897, p. 443.

used subconjunctival injections of a solution of potassium permanganate, with favorable results.

Cuenod[71] used subconjunctival injections combined with mechanical methods in two hundred cases. Corneal complications furnish no contra-indications. Chemosis subsides in three to four days. The method is as follows: The conjunctiva is first scarified or curetted. Then a 1 to 500 mercury cyanide solution, to which is added a few drops of 10 per cent. dionin solution, is injected under the fornix, tarsal conjunctiva, bulbar conjunctiva; and one drop into the caruncle. The after-treatment consists in the use of a 1 per cent. copper sulphate and 1 per cent iodoform ointment.

Schiele[72] rubs the trachomatous conjunctiva with iodic acid (in pencil) and injects a solution of sodium iodate subconjunctivally.

It is impossible at the present time to reach any conclusion as to the value of subconjunctival injections in trachoma. The reports are not sufficiently encouraging to warrant future trial.

MISCELLANEOUS PROCEDURES IN TRACHOMA.

Pterygium occurring in a trachomatous eye greatly hinders recovery and should be removed. Falta *(loco cit.)* has even observed complete cessation of the trachomatous process after excision of a pterygium. Spasm of the orbicularis incident to pannus is favorably influenced by canthotomy; also by forcible stretching of the lids (Hornback).[73] To diminish pressure on the cornea Mulder[74] excises a strip of skin and muscle from the upper lid.

OPERATIONS FOR PANNUS.

There is a wide divergence of opinion among ophthalmic surgeons on the question whether special operative procedures directed against pannus are justifiable or not. MacCallan, for instance, believes there is no treatment for pannus, *per se,* the indication being to improve the lids as much as possible. In very severe cases of trachoma, the cure can only be effected by replacement of the diseased tissue with cicatricial tissue. It is in these cases that pannus is often marked. It is, according to MacCallan, "frequently protective in nature as regards the nutrition of the cornea and should not be interfered with."

It is probable that a distinction should be drawn between "acute

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[71]Cuenod. Sur le Traitement de Trachome, *La Clinique Ophtalm.*, 1907, p. 147.

[72]Schiele. Ueber die Wirkung der Jodsäure beim Trachom. *Klin. Monstsbl. f. Augenheilk.*, July, 1908, p. 96.

[73]Hornback. *St. Louis Medical Review*, June, 1910, p. 173.

[74]Mulder. Operativ. Behandeling van Keratidies Trachomat, en scrophulsa, *Med. Weekblad.*, 1895, p. 180.

pannus," when invading vessels are rapidly advanced to convey much needed nutrition to newly formed ulcers, and what Beard calls "pertinacious vascularity of the superficial portions of the cornea." In the former case the new formed vessels have a definite office to perform. Coincident with an improvement in corneal nutrition their function ceases and they frequently shrivel to mere threads. If, however, they persist indefinitely and remain uninfluenced by treatment directed to the disease, the question of eradicating them by direct surgical attack should be seriously considered.

Furnari[75] was the first to advocate removal of a strip of conjunctiva surrounding the cornea as a means of combating pannus. A broad ring of circumcorneal conjunctiva extending from the cornea to within 3 mm. of the line where the conjunctiva is reflected from the globe to the inner surface of the lid, is dissected up. The subconjunctival tissue is dissected to expose the sclera and the vessels of the cornea are scarified. Finally, the sclera and ulcerated cornea are touched with a strong solution of silver nitrate. The indications for this operation as given by Furnari are as follows: (1) In membranous or fleshy pannus. (2) In phlebectasiæ of the conjunctiva or cornea. (3) In simple vascular keratitis. (4) In interlamellar infiltrations of the cornea. (5) In corneal lesions attending entropion, ectropion and trichiasis. (6) In staphyloma of the cornea.

Agnew (quoted by Beard)[76] practised a similar method, and insisted on a thorough curettage of the episclera surrounding the cornea. The trunks of the corneal vessels were scratched or touched with glowing galvano-cautery where they crossed the limbus. At the dressings the conjunctiva was loosened and pushed back with a blunt instrument.

The operation of peridectomy is thus described by Fox,[77] who has been a most ardent advocate in America of this operation.

"The eyelids are held apart by the speculum and several instillations of cocaine made in order to anesthetize the conjunctiva. A fold of conjunctiva near the cornea is grasped by the fixation forceps and divided by scissors. For partial pannus a band of circumcorneal conjunctiva about 5 mm. wide is dissected on the side of the engorged vessel. If the pannus be general, a complete circular zone must be cut away including the subconjunctival tissue to the sclera in order to form a dike of cicatricial tissue against the convergent vessels. In cases of pronounced pannus a circular incision of the corneal blood vessels by means of a Beer knife is necessary. The appearance shortly after the operation of peridectomy is often alarming, inasmuch as the vessels appear to get a fresh start and the pannus becomes thicker than before. The final outcome, however, is satisfactory. Atropia will have to be used to lessen the photophobia and pain."

Falta *(loco cit.)* cauterizes vascular loops with a galvano-cau-

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[75]Furnari. Tonsure de la conjunctive bulbaire. *Ann. d'Oculist*, 1863. XLIX, p. 272.

[76]Beard. *Ophthalmic Surgery*, p. 353.

[77]Fox. *Diseases of the Eye*, 1904, p. 122.

tery. He declares that curettage of the pannus leads to the formation of dense corneal scars.

Boeckmann[78] advocates the excision of an annulus of conjunctiva followed by vigorous scarification of the subconjunctival and episcleral tissue. The area is then dusted with iodoform. He aims to secure, through the formation of granulations, a scar tissue which will protect the cornea from further invasion of vessels.

Another method of operating in pannus has recently been described by William Primrose,[79] of Glasgow. The point of a small knife is passed beneath the conjunctiva 2 or 3 mm. from the cornea in such a manner as to puncture subconjunctivally one of the large blood vessels. The knife is then withdrawn. By making the wound small and oblique external hemorrhage is avoided. The extravasated blood pressing upon the vessel walls arrests the subconjunctival bleeding. This

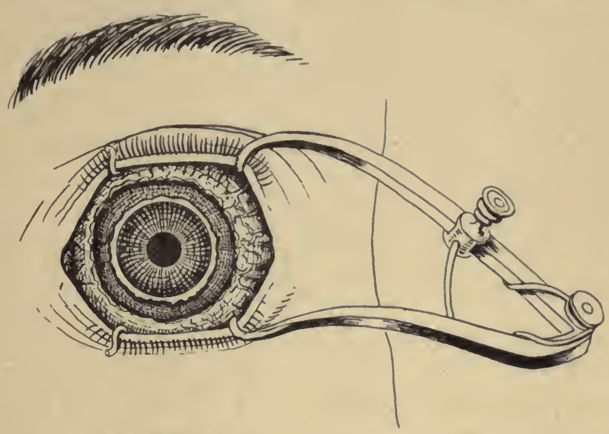

Fig. 445.
Peridectomy.

mechanical action is increased by the formation of a coagulum, the fibrinous part of which shrinks. Primrose describes as follows the rationale of the method: "The extravasated blood acts as an irritant, probably chemical as well as mechanical, so a non-infective inflammation is set up which results in the absorption of the blood clot. This process acts as a counter-irritation to the inflammation of the corneal tissue and so tends to remove the seat of inflammation and the supply of blood from the diseased cornea to the clot, where the effects of the inflammation are comparatively trivial.

By the time the blood clot has disappeared, the blood vessels in the

[78]Boeckmann. Ueber Pannus Trachomatosus und seine Behandlung mittelst Peridectomie der Cornea. Beilageheft zur *Zeitschr., für Augenheilk.*, II, 1899, p. 91.

[79]Primrose. *The Lancet*, April 21, 1906.

cornea affected by the operation have shriveled up and the cornea has regained much of its transparency. The whole pannus may be treated in this way at one time, or the operation may be repeated from time to time only a part of the pannus being treated each time. The latter is always advisable when the pannus is marked, as the inflammatory reaction is sometimes very severe and accompanied by a good deal of pain. Although the structures in the anterior part of the eye ball are all more or less affected by the inflammation, this is easily controlled and subsides in a few days with the application of suitable remedies."

SUMMARY OF TRACHOMA TREATMENT.

Expression of the trachoma bodies is indicated when the follicles begin to show softening, i. e., at the beginning of the second stage. At

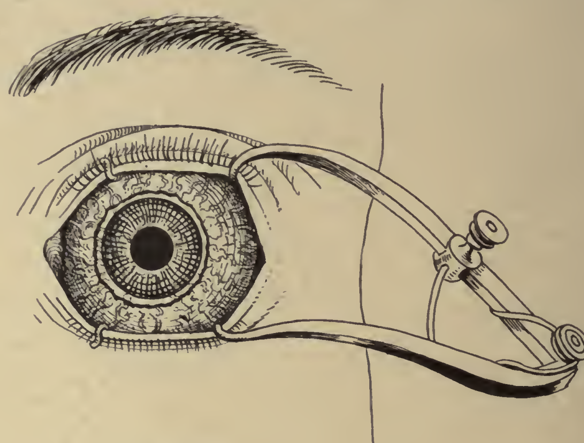

Fig. 446.
Peritomy.

this period expression is the operation of choice. It is contra-indicated in acute trachoma, in cases of follicle formation in the transition fold, during an acute exacerbation and in the cicatricial stage.

Grattage may be used in much the same period and is especially useful when there is much hyperplastic material in the conjunctiva. The method devised by Jameson is useful as an adjuvant to expression.

Coover's sandpaper grattage is applicable to all forms of trachoma. Even in the old cicatricial stages it acts beautifully, smoothing down the rough and hypertrophied portions of the membrane.

Sattler's operation is available in all cases with evident follicular deposits. Chronic cases with thickened lids should be subjected to preliminary medical treatment until the follicles become visible when they should be punctured and curetted. In practice this method has

been largely reserved for cases in which the granulations are isolated and few.

For the obliteration of clumps of little follicles, which are found on the convex tarsal border of the upper lid, and for smoothing out papillary overgrowths on the tarsal conjunctiva, Falta's operation with a dental burr will be found useful.

Massage, either simple or medicamentous, is applicable during the second stage. The unquestioned efficacy of the method is dependent on depletion of the engorged conjunctiva and the smoothing of the roughened surface by repeated abrasions. Doubtless, too, activity of the lymphatics is increased by the mechanical stimulation.

Brossage is indicated whenever the voluminous granulations occupy the cul-de-sac and when the infiltrated conjunctiva is being converted into waxy tissue. Too energetic brushing may result in partial destruction of the conjunctiva and subsequent entropion.

Galvano-cauterism with fine electrodes may, if cautiously employed, be used to eradicate isolated granulations.

Electrolysis after preliminary scarification (Lindsay-Johnson's operation) is useful in chronic trachoma of either the papillary or follicular variety before cicatricial changes have set in.

Simple electrolysis is of only limited applicability.

The *X-ray* has hardly justified the enthusiasm of the earlier experimenters with this method. Some cures have undoubtedly been effected but the majority of cases, even after prolonged radiation, still exhibit granulations.

Radium has undoubted therapeutic value in recent cases. It is useless in the cicatricial stage.

Simple excision of a strip of infiltrated fornix is of value when the tarsus and bulbar conjunctiva are becoming involved, when corneal ulcers appear, and to guard against recurrences.

Combined excision is indicated in long standing cases, in which the lids show trachomatous infiltration and granulation deposits in the connective tissue of the retrotarsal folds; when the tarsus is thickened and enlarged; when the folds and cornea are diseased but without involvement of the tarsus; and when there are deep-seated foci in the tarsus remaining after the cure of granulations in the tarsal folds. The operation is contra-indicated in cases which show a tendency to xerosis.

Extirpation of the tarsus may be performed in cicatricial cases in which the conjunctiva is fre rom disease and overlays a thickened infiltrated tarsus. It may also be employed to remedy moderate entropion.

Subconjunctival injections may have a certain value, especially

when associated with other procedures, such as scarification, curettage, etc.

Auxiliary measures, *e. g.*, the removal of pterygia, canthotomy, forcible stretching of the lids, and excision of skin and muscle from the upper lid may be of benefit in selected cases.

Pertinacious vascularity of the cornea is often greatly diminished or even eradicated by peritomy or peridectomy. Primrose's operation is of too recent date to permit a judgment as to its value. The method, however, seems rational.

[END OF VOLUME I.]